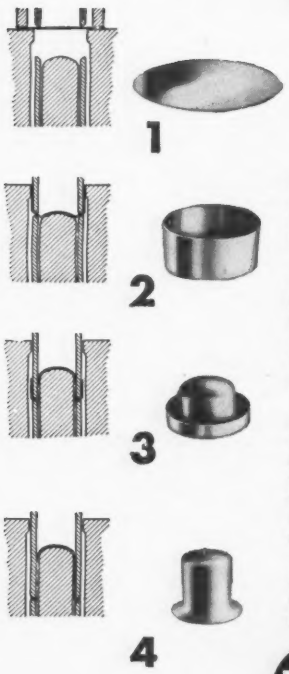
tech engineering news

march 1953

How to turn a high strength steel cup inside out, cold



OFFHAND, anyone familiar with high strength steels would say it couldn't be done. But one of our customers does it every day.

Employing a unique reverse-drawing method and using a U·S·S High Strength Steel especially adapted for this process, they turn out cylindrical containers of various kinds that are not only stronger than those made from carbon steel but weigh substantially less.

To accomplish this, the steel has to meet two entirely opposite requirements. It has to be so strong that it can be used in thinner gages to reduce weight, and yet must have enough ductility to satisfy the drastic fabrication method that would be considered severe even for carbon steel.

This method is used to draw cups for large, low-pressure cylinders. These cups, 14½ in. in diameter and 24½ in. deep, are drawn cold, from 12-gage steel blanks in one continuous stroke in a reverse draw press. The diagrams at left show how it is done.

Starting with a 38 in. diameter steel blank (Fig. 1) the press first draws the steel into a shallow cup (Fig. 2). As the stroke continues, the cup is literally *turned inside out* (Fig. 3) to form the finished cup (Fig. 4) which has very uniform wall thickness. Two of these cups are then welded together to make a cylinder.

Made with high strength steel, cylinders weigh about 20 lbs. less. The maker gets 26% more cylinders from each ton of steel used. Lighter weight makes cylinders easier to handle, and also pays off in lower freight costs—both on the steel from our mills and on cylinders shipped. (A customer 500 miles away saves as much as $100 per carload.)

Developing special steels for special customer needs is an important job of United States Steel metallurgists and engineers. With their tremendous background of practical experience, they are ready to work on any problem that involves the more efficient use of steel. United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

USS

UNITED STATES STEEL

Do you own everything you would like?

If not, perhaps the problem of worker lay-offs could be solved

EVERY MAN, woman and child in America knows of many things he would buy if he could afford them—that is, if the price were low enough. Cutting prices to the point retailers and manufacturers lose money and go bankrupt is no answer. Cutting *costs* is.

Suppose every producer (mine, farm, factory) equipped itself with the most modern productive equipment—and fair tax laws let them save enough to pay for that equipment. Then let every worker use that equipment at maximum efficiency.

Costs would tumble.

Then let business pass those savings on to the public.

Prices would tumble.

Finally, suppose the consumer did his part, and bought. There would be such business as the world never dreamed of. More store clerks would be needed to handle the demand, more transportation workers to haul the goods, more workers to produce them. The more demand and production, the lower the costs and prices; the lower the costs and prices, the more the demand and production. And everyone would have more and more of the things he wants.

Why isn't it done? Greed, fear, misunderstanding.

Honesty, hard work, unselfishness would do it, for the principle has been proven a thousand times. We've tried laws, contracts, strikes, slowdowns—and all we've got is hatreds, shortages, and periodic lay-offs. Is there a leader great enough to rally all America to put this *positive* approach to work? The approach that every honest man knows in his heart is *right*.

There are employment opportunities at Warner & Swasey for young men of ability and character who believe as firmly in the principles of Americanism as they do in the principles of sound engineering. Write Charles Ufford.

YOU CAN PRODUCE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY MACHINE TOOLS, TEXTILE MACHINERY, CONSTRUCTION MACHINERY

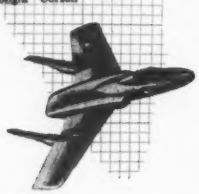
Your Future as a Chance Vought... engineer

Chance Vought Aircraft, a designer and builder of military aircraft for 35 years, offers the graduating engineer and scientist an opportunity to join in the design and manufacture of fighter aircraft and guided missiles.

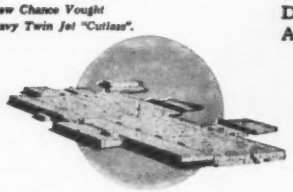
The design of fighter aircraft is constantly being improved as new materials and more powerful engines become available. Guided missile design is in the pioneering stage and progress up to this point, in our opinion, can be compared to the period of development of piloted aircraft prior to World War I. Imaginative thinking as well as sound engineering is an important part of these programs. The young engineer through his creative thinking can rapidly assume a position of engineering responsibility in the Chance Vought organization.

If you are receiving a degree in Aeronautical Engineering, Mechanical Engineering, Civil Engineering, Electrical Engineering, Mathematics or Physics, Chance Vought invites you to discuss your future in these fighter aircraft and guided missile programs. Contact your Placement Director for an appointment with the Chance Vought Aircraft representative.

Famous World War II Chance Vought "Corsair"



New Chance Vought Navy Twin Jet "Cutlass".

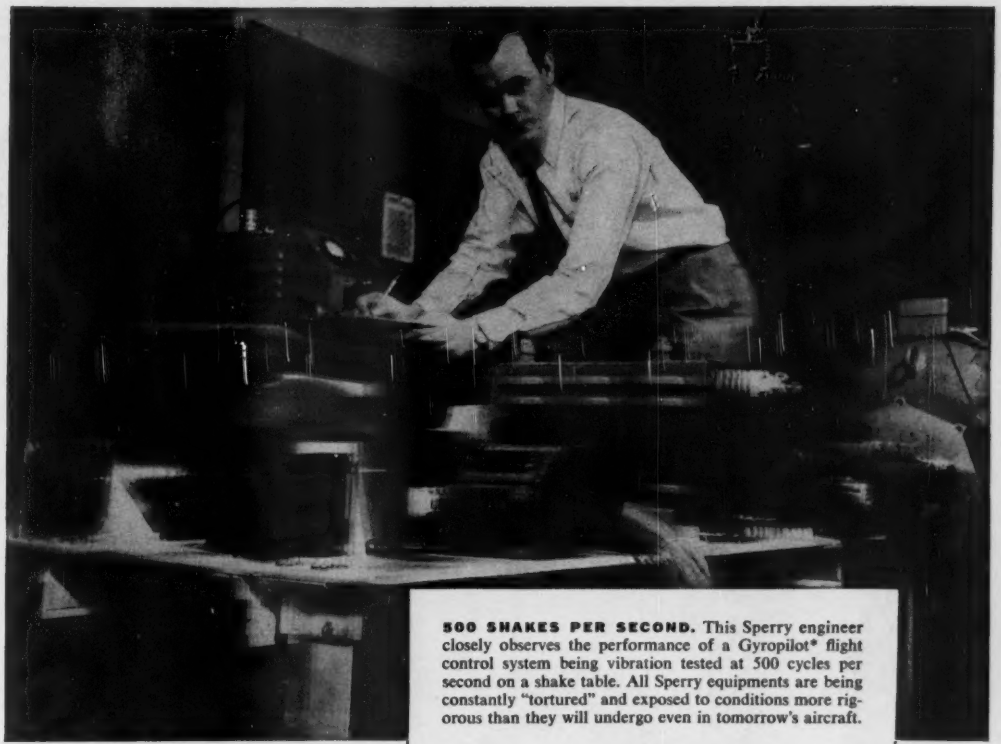


Chance Vought's completely air conditioned, modern plant.

CHANCE VOUGHT AIRCRAFT

Dallas, Texas

DIVISION OF UNITED AIRCRAFT CORPORATION



500 SHAKES PER SECOND. This Sperry engineer closely observes the performance of a Gyropilot* flight control system being vibration tested at 500 cycles per second on a shake table. All Sperry equipments are being constantly "tortured" and exposed to conditions more rigorous than they will undergo even in tomorrow's aircraft.

Things are on the move at Sperry

...WITH EXCELLENT OPENINGS AND TOP SALARIES FOR GRADUATE ENGINEERS!

How would you like to start right in working with leaders? . . . That's what *you* can do at Sperry.

You enjoy good pay as you keep on learning—in research, product development, or field work. You'll be expected to use originality and a fresh approach to every problem. And as a member of the Sperry engineering staff, you'll have continuing creative challenge.

CHOICE OPENINGS FROM WHICH TO CHOOSE

Diversity is the word . . . openings for aeronautical, electrical, electronic, mechanical engineers—physicists—technical writers and field engineers for applied engineering.

ATTRACTIVE LOCATIONS

Long Island—A pleasant suburban atmosphere convenient to New York. Modern plant. Well-equipped laboratories. Excellent working facilities.

In the Field—There are excellent applied engineering opportunities in various sections of the United States and abroad.

GOOD WORKING CONDITIONS

The way is clear for steady advancement. You are encouraged to continue your education while you earn. And liberal employee benefits are provided for all.

AHEAD FOR FORTY YEARS!

Sperry research leadership has led the industry for more than a generation. Today Sperry is the recognized leader in developing automatic controls for navigation. From Sperry's work in gyroscopics and electronics have come the Gyropilot* flight controller, Zero Reader* flight director, radar, servomechanisms, computing mechanisms and communications equipment.

CHECK YOUR PLACEMENT OFFICE FOR DATES WHEN SPERRY REPRESENTATIVES WILL VISIT YOUR SCHOOL . . . OR WRITE SPERRY EMPLOYMENT SECTION 1A5.

*T. M. REG. U. S. PAT. OFF.

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SAFETY FIRST

tech engineering news

March 1953

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FRONTISPIECE

Antennae

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Out of the grimy scrap pile come

BETTER STEEL PRODUCTS

How Republic Steel Research is Helping Machine Tool Users...and You!

● An oily mess of steel chips under a machine! So much steel scrap? . . . Yes, but scrap that can tell an important story about the machinability of steel.

Republic metallurgists know that. So they take samples of chips cut from various steels. They study them—measure changes in hardness—right down to each tiny grain of steel.

That's just one of the ways in which Republic has learned so much about the intricacies of steel. There are many others—each a part of Republic's continuous program of research to improve its 3-FOLD SERVICE FOR STEEL USERS.

Here it is:

1. Production of the *best-possible* steels and steel products—thousands of them.
2. Recommendation as to which steel or steel product will do a specific job best.
3. Assistance in developing the most efficient and most economical method of processing or fabrication to achieve the desired end result.

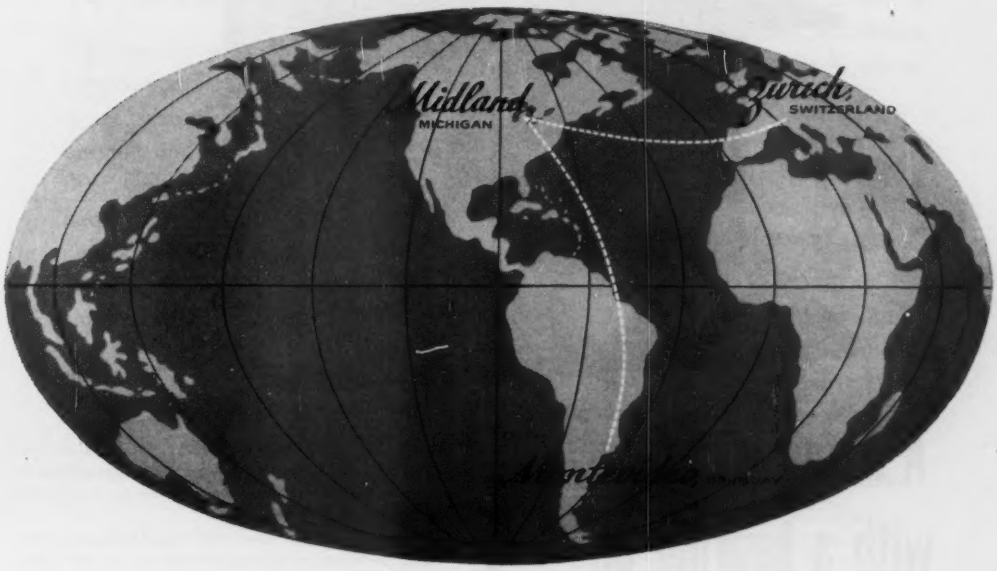
This doesn't necessarily mean that Republic works miracles for steel users . . . but it does mean that Republic keeps alert to changing requirements—that Republic is vitally interested in its customers—and that these working policies help to make Republic a good place to work, a good place to stay.

REPUBLIC STEEL CORPORATION
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC STEEL

DOW ADDS NEW EXPORT COMPANIES

Dow has recently formed two subsidiary export companies to serve foreign industry's increasing demands for high-quality chemicals.



In the Western Hemisphere, Dow Chemical Inter-American Limited with sales offices in Montevideo, Uruguay will supply chemicals to Mexico and to many countries in Central and South America.

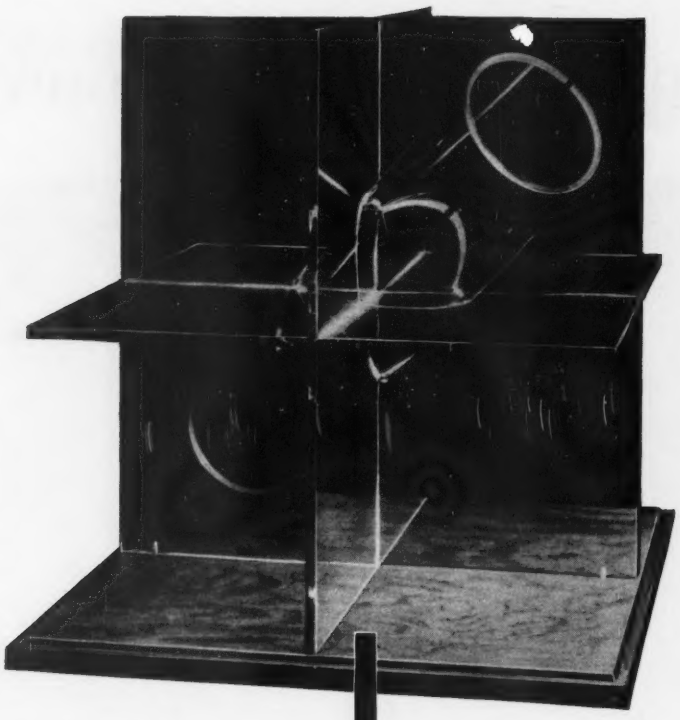
Industries in other continents—Europe, Asia, Africa, and Australia—will be served by Dow Chemical International Limited. Its first sales office will be in Zurich, Switzerland.

These two new export companies are only one example of the continued growth taking place at Dow. Each year finds new Dow plant facilities, increased production, new products developed . . . an over-all growth and expansion that requires a steady influx of men of varying talents, as well as providing excellent opportunities for those within the Dow organization.

Dow's Booklet, "Opportunities with The Dow Chemical Company," especially written for those about to enter the chemical profession, is available free, upon request. Write to The Dow Chemical Company, Technical Employment, Midland, Michigan.

you can depend on DOW CHEMICALS

DOW



A Bearing Theory with a bearing on your job future

The futuristic-looking object in the picture above is a demonstration model of Maxwell's distortion energy theory concerning the yielding of ductile materials.

And it's used by our General Motors research engineers in their study of "bearing fatigue."

From this study they have succeeded in discovering new facts about the "thick and thin" of bearing surface metals—and thus added to wearing qualities of journal and engine bearings.

We publish it here to point up a fact that should not be overlooked by the engineering student with a bent for research.

That fact is the wealth of opportunity for the research-minded engineer to function creatively at General Motors.

Yet research engineering is only one of the opportunities at General Motors for the graduate engineer.

For GM is not only a leading producer of motor-cars and trucks. It also manufactures many other types of civilian goods from heating and air conditioning systems to refrigerators, from fractional h.p. motors to Diesel locomotives.

And, as a top defense contractor, GM builds everything from rockets and range finders to jet and Turbo-Prop airplane engines.

So there's plenty to work on at GM. And plenty of engineering brains to work with.

Our many graduate engineers in top management prove that the engineer with the ability to make real use of what GM has to offer can build himself a very satisfying future in the GM family.

So why not ask your College Placement Office to arrange an interview for you with the GM College Representative the next time he visits your campus? Or drop us a line.

GM Positions now available in these fields:

MECHANICAL ENGINEERING • ELECTRICAL ENGINEERING
METALLURGICAL ENGINEERING • INDUSTRIAL ENGINEERING
CHEMICAL ENGINEERING

GENERAL MOTORS

Personnel Staff,
Detroit 2, Michigan

Pioneers Wanted

A YOUNG MAN with vision is a priceless part of our future.

This we know at Goodyear Aircraft Corporation, for our record achievements — as America's only producer of both heavier- and lighter-than-air craft and their components — is due in a large measure to the pioneering of young graduate engineers who came to us, casting about for a place where they could best put their talents to work.

They found it at Goodyear Aircraft, a place that offers every engineer an opportunity to specialize in the work of his choice—a place that encourages the forging of new "firsts" and new futures in new fields.

They found a future that is as secure as it is challenging—for Goodyear, as one of the nation's basic industries, will always be doing business come defense, war or peace.

Today Goodyear Aircraft Corporation is offering opportunities in fields ranging from plastics to electronics, from metallurgy to aerodynamics—for young men of vision seeking an assured future.

We are interested in you if you are interested in pioneering new horizons. Submit a brief resumé of your experience and qualifications, or write us for an application blank and further information. Address: Salary Personnel Department, Goodyear Aircraft Corporation, Akron 15, Ohio.

ENGINEERS WANTED

to investigate the opportunities in research, design and development and production of: AIRPLANES AIRSHIPS • HELICOPTERS • GUIDED MISSILES • ELECTRONIC COMPUTERS • AIRCRAFT COMPONENTS GUIDANCE SYSTEMS • TRANSPARENT ENCLOSURES • REINFORCED PLASTICS • RADOMES • BONDED SANDWICH STRUCTURES • WHEELS AND BRAKES • RADAR STRUCTURES and many others.

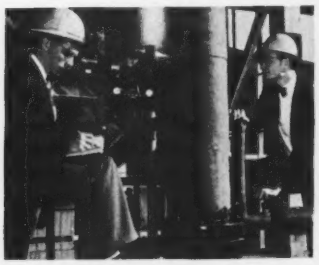
GOODYEAR—*The Company with COMPLETE Coverage of the Aeronautical Field*

THE DU PONT DIGEST

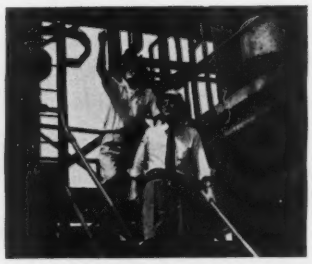
THE ENGINEER'S PLACE IN

Plant Development

Another phase of Du Pont production activities offers challenging work for the technical man



E. H. Ten Eyck, Jr., *B.S. in Ch.E., Syracuse '43, Ph.D. in Ch.E., Brooklyn Polytech '50, and W. H. Stevens, Jr., B.S. in Ch.E., Yale '50, take recordings on a new nylon unit.*



D. S. Warner, *B.S. in M.E., Purdue '47, and G. R. Prescott, B.S. in Met. E., Columbia '49, discuss improvements for stainless steel liners in tubes carrying corrosive materials.*

In most Du Pont manufacturing plants you'll find two groups of engineers working side by side to make operations more efficient—to reduce costs and improve quality. The specialized work of one group, the production supervisors, has been rather fully discussed in the *Digest*.

Equally vital is the work of development men—the men responsible for advising management when operational changes should be made for economic or technical reasons.

Engineers from several fields of training are employed in development activities at Du Pont. It seems to have a special appeal for the man who can take on a big problem, analyze its parts, and come up with a thoughtful, reasoned solution.

Individual development studies may begin in a number of different ways. Often they are sparked by the imagination of the engineer himself, who, of course, must be familiar with production costs, activities of competition, and recent or impending technical improvements.

Studies also may be inspired by suggestions of production supervisors or sales personnel, obsolescence of equipment, advances in competitive products, or the presence of unsatisfactory profit margins.

John Purdom, *B.S. in Ch.E., Ohio State '49, and Kenneth Kehr, North Carolina State '50, discuss diagram of a process for improved recovery of an intermediate for high polymers.*

In a single study, the engineer may draw data from laboratories, semi-works and plant-scale experiments, prepare an estimate of profits and investments and consult with numerous specialists on various phases of the problem, both within the Company and outside.

Having collected data from these many sources and perhaps from an independent study of his own, the plant development engineer must then assemble and evaluate the material and prepare a recommendation that is based on sound engineering judgment.

Whether a product or process improves from the standpoint of competition, profit and efficiency depends, in great degree, on the quality of its plant development work. The development engineer's job is a responsible one at Du Pont, and the work of a good man is soon noticed.

HAVE YOU seen "Chemical Engineers at Du Pont"? New book describes initial opportunities in many fields, tells how experiences are varied to prepare men for administrative and management positions. For copy, write 2521 Nemours Bldg., Wilmington, Delaware.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Listen to "Cavalcade of America," Tuesday Nights on NBC—See It Every Other Wednesday on NBC TV

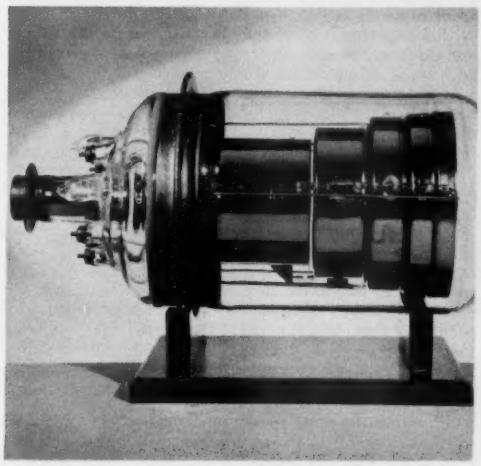
briefing the news

X-ray image amplifier . . .

Radiologists and physicians now have a new tool in the x-ray image amplifier — a device that will give them a two hundred times brighter view of their patient's internal organs in living action. An attachment for standard fluoroscopic equipment, the image amplifier is now going into production after eight years of intensive research. Basically, the amplifier consists of a high-vacuum tube that electrostatically focuses and accelerates an electron stream.

The new image amplifier increases the brightness of the fluoroscopic image after the x-rays have passed through the patient. This solution to the problem is necessary because the x-ray intensities are already approaching the patient's tolerance level. Since fluorescent screens have a gross efficiency of about five per cent, even a theoretically perfect screen would be only about twenty times as bright, and screen improvement alone cannot achieve the desired brightness gains.

Increased brightness of the x-ray image has been attained by converting the x-ray energy into light with



a fluorescent screen, and thence to electrons by means of an adjacent photoelectric surface. These electrons are accelerated by a high potential placed across the vacuum tube, giving a brightness gain of ten or more. A further gain is attained by electrostatic focusing of the electron stream to reduce the image to approximately one-fifth its original size. The reduced image impinges on a phosphor output layer that converts the electron stream back to a visible image, now brightened two hundred times or more. As a final step, the intensified image is magnified by means of an optical system without loss of the increase in brightness.

The future possibilities for fluoroscopy with the addition of amplification are manifold. In addition to shorter examinations, such techniques as stereofluoroscopy and even the televising of fluoroscopic images may become practical. All these possibilities are in addition to the great advantage that the physician will be able to perceive objects that are presently indiscernible.

Now commercially available, the image amplifier can be used as an attachment to present-day x-ray fluoroscopic equipment. Since all the work is done after the x-rays leave the patient, the new development will in no way affect the basic design or operating principles of equipment now in use.

"Canned" motors in atom sub . . .

Motors driving hot-water circulating pumps for a nuclear reactor are, literally, canned. The squirrel-cage rotor is contained in a shrink-fit jacket of steel. It turns within a stator that likewise is fully enclosed in stainless steel. In this type of a motor, the term "air gap" cannot be used as it is a combination of water and two layers of metal. Both the stator and the rotor are encased in stainless steel, and the space between is filled with flowing hot water, the same fluid that is being pumped through the reactor circuit.

As with most of the components of the reactor circuit, leakage must be small. Hence the motors cannot drive the pumps through seals. The rotor must be contained within the fluid circuit, and obviously is continuously exposed to water that is hot both as to temperature and radioactivity. To prove tightness, the stator enclosure is tested with the most sensitive leak detector obtainable. The space to be occupied by the rotor is filled with helium under a high pressure and with the stator volume evacuated. The bearings also are inside the stator and are lubricated by water.

As if these many unusual requirements were not enough, the whole packaged unit — motor and pump built integral with it — must pass the Navy test for high shock. One unit is presently undergoing shock tests and has to date survived five blows of relatively severe intensity without any visible or operational damage. A smaller unit has been running for thirteen thousand hours continuously under conditions of full load, operating temperature, and pressure.

Optical wedges . . .

The principle that makes the earth warm in summer and cold in winter has been employed by a scientist to construct a unique apparatus for making optical wedges. Such wedges, opaque at one end and shading to transparency at the other, control and measure light intensity in optical experiments.

In search of a means for measuring the light intensity and thus the temperature of rocket motor flames, a laboratory physicist could find no commercially-produced wedges of the proper size and type. He hit upon the idea of exposing photographic film on the same principle that makes the sun's rays hot in summer when the sun is high overhead, and cool in winter, when the sun is low in the sky. He constructed a carefully-curved surface to hold the film so that parallel rays of light could strike it at varying angles over its entire length. The device is equipped with a lamp and lens to supply horizontal rays of light in a parallel pattern. This light strikes the near end of the film directly, but only grazes the far end. The result is a film strip which is completely transparent at one end, but gradually shades into complete opacity at the other. By changing the shape of the curved film holder, densities in the film can be varied to suit changing requirements. Once set up, the device can produce many such wedges with little effort and at slight cost.

Ordinarily these wedges are made of optical glass by a painstaking and expensive process. Some have been made on film by slowly withdrawing a cover from the

film strip, with a light shining vertically on the strip. This new method is less time consuming and expensive, and is believed to be more accurate as a method of obtaining a desired gradation of exposure. Optical wedges are used extensively in research for measuring and comparing the brilliance of light sources. They also are valuable tools for calibrating the sensitivity of photographic film.

Jet engines "canned" for shipment . . .

Completed jet engines are "canned" for shipment in these special skid-mounted containers, which open at the center to simplify insertion or removal of engines. The containers are specially devised for protection during shipment and for safe long-time storage under the worst atmospheric conditions in the field. Before shipment most of the air is evacuated from the containers, then five pounds of dry air is pumped back in. The cans are mounted on air-filled rubber cushions, and are fitted with lifting grommets for easy handling with a crane or winch.

Digital computer . . .

A new electronic computer with one of the largest "memories" yet incorporated in any computing device is ready for use. The brain of the computer is a metallic drum which can hold pulses representing ten thousand ten-decimal numbers on its magnetized surface until the numbers are called into use. The new digital computer, known as the "OARAC" (which stands for Office of Air Research Automatic Computer), can deliver rapid-fire answers in typewritten form to mathematical puzzles which would take expert mathematicians years to solve. It can make as many as one hundred calculations per second.

The new computer will be used by the United States Air Force's Research and Development Command at its Flight Research Laboratory, Wright Air Development Center, Dayton, Ohio. The new computer will be used by Air Force in solving complex problems involving aircraft design, guided missiles and ballistics. OARAC will save valuable research and development time, equipment and money by eliminating much costly flight testing of experimental aircraft equipment. For example, OARAC will decrease the flight test time required in the development of improved auto-pilots.

There is more to solving a highly-complex problem than merely feeding in numbers and getting an answer, however. Each problem must be carefully programmed in advance so that the instructions on what to do and how to do it will be fed in in a logical sequence. With some problems, the programming may take longer than the actual solution. The memory cylinder, which holds the numbers until they are ready for use, also holds instructions telling what to do with the numbers when they are called into play. Both the numbers and instructions can be wiped off or left on the drum as long as desired. Information — that is, numbers and instructions — is fed into the machine by typewriter on an input unit which puts the information on magnetic tape, from which it is transferred to the memory drum. Answers coming out of the computer are received on magnetic tape and printed on an automatic typewriter.

Another important feature of the OARAC is the push-button panel which is used for regular checks on the operation of the computer. The panel can also be used for the solution of relatively simple problems. The operator merely pushes a series of buttons representing the various numbers involved, pushes another button which tells the OARAC what to do with the numbers — either to add, subtract, multiply, or divide — and the answer is indicated in a tiny fraction of a second on a series of lights at the top of the panel.

An important use of the OARAC will be in solving repetitive problems. For example, in calculating certain types of mathematical curves, a mathematician might have to do the same problem over and over again, with only a slight variation each time — a process which might take him years. The computer could hold the constant numbers on the memory drum, take the slight variations into account, and calculate the answers in a matter of hours.

One of the most significant features of the new computer is its ease of maintenance. About 1,400 electronic tubes, a relatively small number for a machine of this type, and about 7,000 germanium diodes are used. The tubes are incorporated in a series of plug-in "turrets," each of which is a complete circuit in itself, designed to perform a complete function. Seven different types of turrets are used in the OARAC, each representing a different type of operation. In case of failure, the operator merely has to replace the faulty turret to set the machine in operation again.

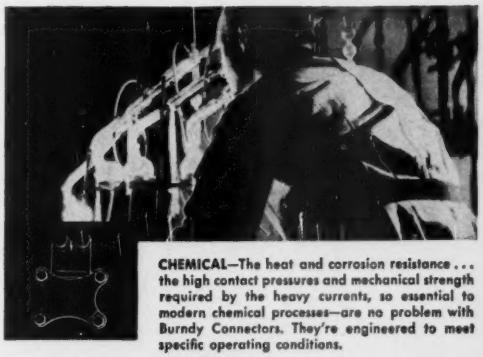
X-rays for wheat . . .

Newest "criminal" to fall victim to scientific detection methods is the lowly but destructive wheat weevil now being tracked by X-ray's penetrating eye. The bug, which sometimes resides inside a grain of wheat, has been brought out into the open by the development of a new grain inspection X-ray unit.

The new unit can accomplish a complete test of the wheat in approximately fifteen minutes, while the best recorded time for other models is twenty minutes. In making the test, about a handful of wheat is placed in a tray and radiographed. After developing, the picture is read for the telltale black surface specks that result from newly-laid weevil eggs. If the eggs have hatched and the larva has burrowed inside the shell, the tunnel and body are easily detected by the different shadings of the wheat grain.

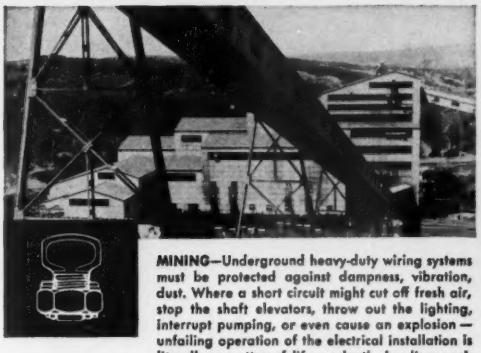
Principal among the features of the machine which will make the grain inspectors' job easier is the high rating of the X-ray tube which gives a picture in half the normal time for such machines and its compactness.

Wherever there's electricity... you'll find Burndy connectors on the job!

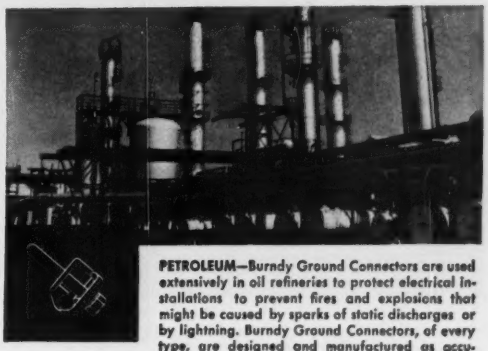


CHEMICAL—The heat and corrosion resistance... the high contact pressures and mechanical strength required by the heavy currents, so essential to modern chemical processes—are no problem with Burndy Connectors. They're engineered to meet specific operating conditions.

UTILITIES—Burndy serves the utility industry with 140 standard types of Power Connectors... for cable, tube, bar and special shapes... for copper and aluminum conductors... in power stations, in overhead and underground installations. Burndy equipment is *basic* in utility connecting systems.



MINING—Underground heavy-duty wiring systems must be protected against dampness, vibration, dust. Where a short circuit might cut off fresh air, stop the shaft elevators, throw out the lighting, interrupt pumping, or even cause an explosion—unfailing operation of the electrical installation is literally a matter of life or death. Leading engineers specify Burndy Connectors.



PETROLEUM—Burndy Ground Connectors are used extensively in oil refineries to protect electrical installations to prevent fires and explosions that might be caused by sparks of static discharges or by lightning. Burndy Ground Connectors, of every type, are designed and manufactured as accurately as those which are called on to carry current continuously.

Burndy Connectors are specified because of their superior performance in joining, terminating, clamping, and grounding every size and functional variety of electrical conductor—from the smallest home wiring circuit to the largest industrial installations. Burndy engineering is continuously developing more and more efficient connecting methods. *Engineering graduates and students are welcome visitors at Burndy Connector Headquarters.*

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AUSTIN BUSH, inspecting stuffing box assembly on boiler feed pump.

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WORTHINGTON

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2.54X

What's Happening at CRUCIBLE

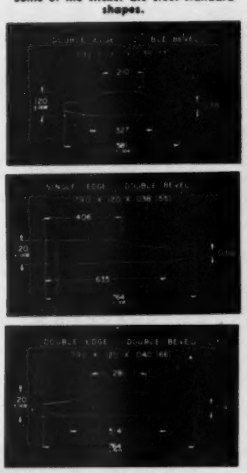
about clicker die steel

what it is

Clicker die steel is a special cold rolled alloy steel. It is used in making clicker dies for cutting leather, rubber, plastic, felt and fabrics of other compositions that go into the making of shoes and similar products.

Finished clicker die ready for cutting shoe leather.

Some of the clicker die steel standard shapes.



Wider shapes are used when dies are sized by surface grinding after forming and welding. Standard widths are provided when the dies are not to be surface ground.

how it is used

Clicker die steel is furnished to the die maker in either single or double edged form in one of several standard shapes. The die maker first shapes the die by bending the die steel to a pattern that provides the desired configuration, and then welds the two ends at a corner. He finishes the die by grinding a bevel on the outside of the cutting edge and filing the inside edge. Before the finished die is hardened and tempered, the die maker forms identification marks – combinations of circles and squares – in the cutting edge so that the material cut from it may be easily identified as to its size and style.

In the cutting operation, the leather or other material is placed on an oak block in the bed of the clicker machine. Then the die is placed by hand on the material which is cut as the aluminum faced head of the machine presses the die through it. The clicking sound which the head makes as it strikes the die is where the term "clicker machine" derived its name.

what it is composed of

Clicker die steel as produced by the Crucible Steel Company of America is a controlled electric steel in which the combination of carbon and alloy is designed for maximum toughness and proper hardness after heat treatment.

Experience has proved that cold finished clicker die steel is superior to hot rolled material for sizes approximately ¾ inch and narrower because of its lower degree of surface decarburization which permits the use of slightly thinner sections. Cold finished material also has a better surface finish with closer width and thickness tolerances and thinner edges that require less grinding and filing to complete the die.

CRUCIBLE'S engineering service

As with clicker die steel, the Crucible Steel Company of America is the leading producer of special purpose steels. If you have a problem in specialty steels, our staff of field metallurgists with over 50 years experience in fine steel making is available to help you solve it. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

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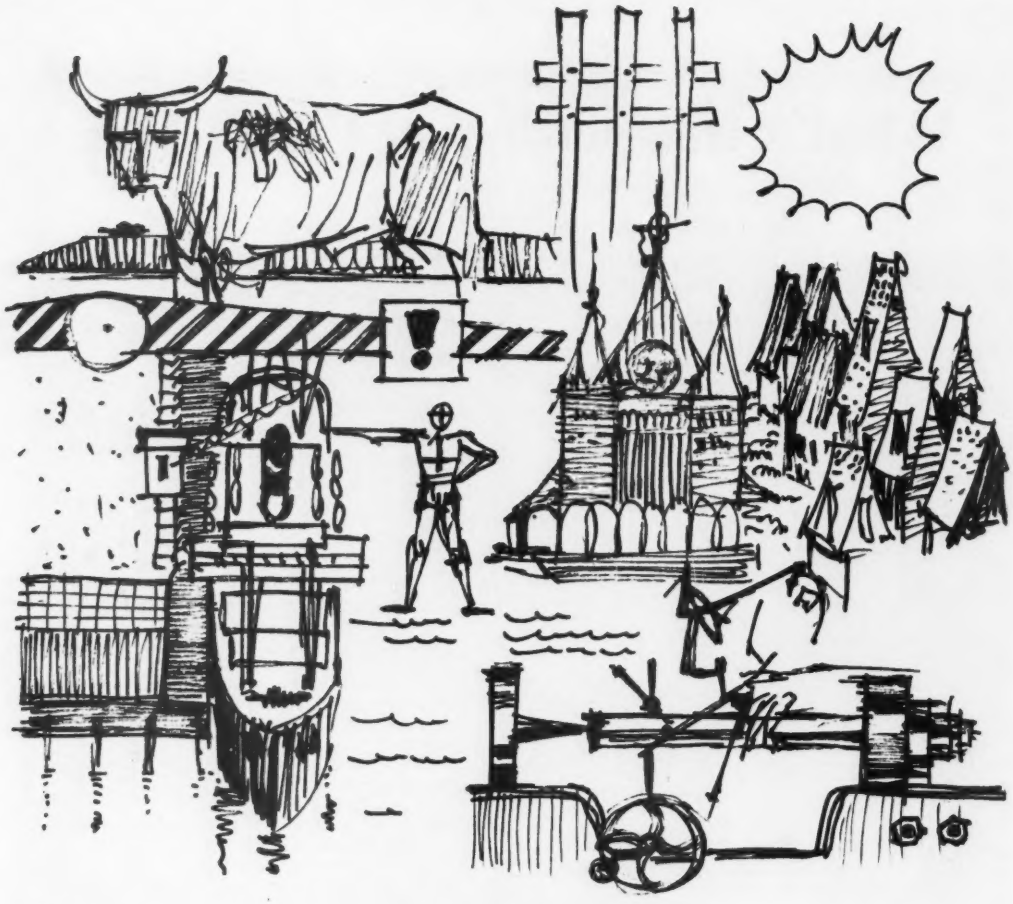
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin



the structure of autonomy

By Karl W. Deutsch

Professor of History

The discussion in this paper will be centered on the social sciences, and will contain few explicit references to other fields of study. Yet its broader background should be admitted at the start. Background material for this study can be found in four areas of experience: First, in the social sciences, as data on the structure and behavior of various political and social organizations; second, in history, as data on the behavior of various peoples, nations, and civilization and as ideas found in the history of philosophy and of religion; third, in the theory of communications and control, as data on problems of self-steering processes and devices; and fourth, in psychology and neurophysiology, as data on the behavior of the human or animal body, and of human beings.

Different investigators have drawn upon these various resources in different proportions. Between them, they have produced a growing body of thought, which appears to have applications to social science. The present paper will be confined largely to this latter field and within it to the problems of self-steering or autonomy and their possible significance for some of our ideas of democracy, authority, and freedom.

At the outset, we may assume tentatively that self-determination or autonomy is a special case of the problem of steering, and that problems of steering show significant similarities, whether they are found in the case of a man walking, or a ship navigating at sea, or a social group arriving at a decision, or an organization formulating and executing policy. Some of the fundamental problems of steering will be common to all these instances; some of the more complex higher order problems will be peculiar to the more complex types of organization.

One fundamental problem of steering, common to all cases, is an output of relatively large scale physical

changes — a rearrangement of physical facilities — in response to an input of information. This requires not only a set of physical facilities for steering, but also a set of intake channels functioning like sense organs in an organism, in receiving information from the outside world; and it requires further a set of internal communications, channels linking the intake of information to the output of steering behavior of the organization. The maintenance of such a system of intake facilities and inner communication channels represents a second type of problem common to all organizations in which steering occurs.

A third characteristic common to all steering systems is the presence of values, that is, of priorities in the reception and transmission of messages in the intake facilities and inner communication channels of the organization. Such values need not be formulated in words; they are implicit in the character and arrangement of the system. No steering system could be built, or even imagined, which would receive and treat impartially all information in the universe. It must, of necessity, select a smaller and more manageable part. If it is to function, the organization must somehow discriminate, at least to some extent, between the near and the far away, between message and noise, and between the relevant and the trivial. If it does so abstract and discriminate, according to any relatively stable pattern, then this pattern represents, in a sense, the operating values of the organization.

1. *Autonomy and Internal Communication*

What, we may ask, is such an organization? What holds it together and what separates it from its surroundings? In the case of a single ship or a single organism, such as a single human or animal body, the answer seems quite simple: there are physical bonds holding the unit together, and physical gaps separating it from everything else. Selfhood in a single organism would then consist in being held together by such bonds and being surrounded by such gaps.

If this would have been a doubtful test already in the case of the famous Siamese twins, Chang and Eng, who were two distinct persons although their bodies were linked, it becomes far more doubtful in the case of any social group or organization. Here the bodies of the individuals making up the group are separate from each other, and some or even all of them may be physically nearer to the bodies of non-members of the group than they are to each other.

Rather, what holds members of such groups together is their "social cohesion," or more accurately, their complementarity of communication, or their ability to transmit relevant messages more accurately to each other than to anyone else. Such complementarity may be implicit in the physical pattern of the organization, as in the layout of telephone lines, or of streets in a city. Or it may be given by the specific social structure of the organization, such as the chain of command in an army, the routing of documents in a research organization, or the line of authority in business enterprise. Finally, it may be embodied in the communications habits or character structure of each individual, as in the cases of language communities and peoples.

As some degree of external separateness and inner communication is implicit in the functioning of any self-steering system, they are, in that sense, part of its operating values. We may look upon such values from the outside as observers, or from the inside as participants. In the latter case, such operating values may appear to us as our own feelings. In our bodies, we may experience them as feelings of health, good coordination, and freedom from external physical restraints. In our organizations we may experience them as *esprit de corps*, as team spirit, as morale. In our social groups, tribes, and nations we may experience them as a sense of "we-feeling" or "belonging," or in more extreme but frequent cases, as "ethnocentrism" or "in-group" feeling.

The common characteristic in all these cases is the differential treatment of information: its markedly more efficient transmission within the group or organization, compared to the treatment of information coming from without. Would an increase in this differential bring with it an increased cohesion of the group? We cannot answer "Yes" without qualifications. The differential could be increased by improving the transmission of information within the group, or by reducing the acceptance of information from without. It is the former rather than the latter method which promises significant gains in autonomy. A thicker skin is not a substitute for health. Nationalists have often considered dislike of foreigners an inexpensive substitute for genuine mutual knowledge and sympathy among their own people, but usually it has been complementarity and cooperation among their own people which proved indispensable to winning and maintaining self-determination or self-government. Thus, according to a recent investigation, the landowners of Virginia came to think of themselves as Americans after 1763, not because they had cut themselves off from Britain during the preceding years, but rather because they had come to form a so much more closely knit community in their own country.

Selfhood of a group or organization, at this extremely simple level, would be located mainly in the set of channels of inner communication; if these should cease to function the group would no longer hold together or respond to messages.

2. *Autonomy and Feedback of Data from Observation*

Inner communication and relative external separateness are necessary conditions for autonomy, but they are not sufficient. If an organization is to be self-steering — rather than merely capable of being steered — then its communication channels must include a feedback loop. A feedback loop is an arrangement of channels such that the input of information to the organization includes data about the organization's own performance in the outside world, and, in particular, of its own position relative to a goal situation in that outside world. A goal, in this context, is such a relationship of the organization to the outside world that some internal tension, or, more accurately, disequilibrium, within the organization shall be at a relative minimum. This information about the extent to which the organization has as yet fallen short of its goal (or to which it has overreached it) is then fed back into the steering of the further output of the organization. Self-steering requires, thus, a certain amount of self-observation, and at the same time observation of the outside, and the seeking of some goal in the latter.

Seeking such a goal may be merely implicit in the configuration of communications channels within a social organization. Or the goal may be explicitly labeled and known as a value to the members — with consequences to be sketched below. In either case, selfhood at this level would be located in the set of channels making up the feedback loop, and it could be destroyed (or reduced to the preceding lower level) by their destruction.

3. Goal Changing and Memory

The simplest type of self-steering just discussed involves the seeking of a single goal, or of goals from a single class of goal situations, implicit in either case in the layout of the communication channels. An organization might have far more autonomy, however, if it could change its goals. Goal-changing feedback requires some sort of second order feedback loop, such as a feedback loop which accepts information about the reaching or approaching of the first goal (determined by the first feedback loop), and uses this information *to change the configuration of the channels themselves*, so as to put a new goal in the place of the first. Values at this level appear in the organization as priorities among the various first order goals; and selfhood, or the highest type autonomous control within the organization, would now be located in the channels making up the goal-changing circuit.

Goal-changing feedback with much richer results depends on facilities for memory and recall. If information from the outside can be stored somewhere within the organization and recalled later, so as to be fed back eventually into the determination of subsequent output, a wider range of control of its own behavior becomes possible for the organization. Such storage may be in the heads of individuals, or the memory function may be institutionalized in written records, files, and libraries. In either case, memory and the data recalled from it must be given priorities, at least in some situations within the organization. Memory, the past, tradition, thus become operating values, whether or not they are distinctly so labeled. Selfhood at this new level depends on memory, and is lost with the loss of the latter.

The importance of memory is the greater, and the effects of its loss the more severe, because a functioning memory implies the probability of eventual *individuation*. Two organizations might set out with exactly the same structure, and yet the different data and experience from the outside world, recorded in the memory facilities of each organization, would eventually produce different stocks of memories in each, and, with these, eventually the probability of different data recalled and different kinds of behavior shown by each of the two organizations, even in the presence of similar or identical stimuli.

Goal-changing organizations would be in some significant sense more permanent or more important than some of the different goal situations which they happened to pursue at this or that time. If, moreover, the changing of their short range goals should depend on the data recalled from their memories, then such organizations might function in some respects somewhat similarly to individuals with peculiarities of personality; and as their memory-guided behavior might, in turn, influence their intake and storage of subsequent memories, such organizations might be capable of considerable internal evolution.

4. Initiative and Consciousness

Memory — however short — is the foundation of novelty and of initiative. The essential steps toward novelty and initiative in an organization are taken as four.

First, that some information should be stored, and stored analytically, that is to say, that it should be stored in separate parts, at least some of which could be recalled independently from others.

Second, that on recall they should be recombined in new patterns — either new only for this particular organization, or even new for the entire surroundings in which the organization had been functioning thus far.

Third, that the new pattern "proposed" by the recombination of old elements should be matched, in its turn, by a new secondary symbol which would match the most characteristic features of the new pattern, but without preserving any longer the traces of its combinatorial origin; this step is decisive in producing novelty. We might say that novelty is produced by sequences of analysis, combination, and abstraction.

Finally, the fourth step, that the new pattern should be fed back into the determination of the subsequent behavior of the organization. This feedback of novelty into behavior we may call *initiative*.

If the new behavior resulting from initiative should, in its turn, lead to the production of a new pattern in the material or social *surroundings* of the organization, we might even speak of *creativity* or creative behavior.

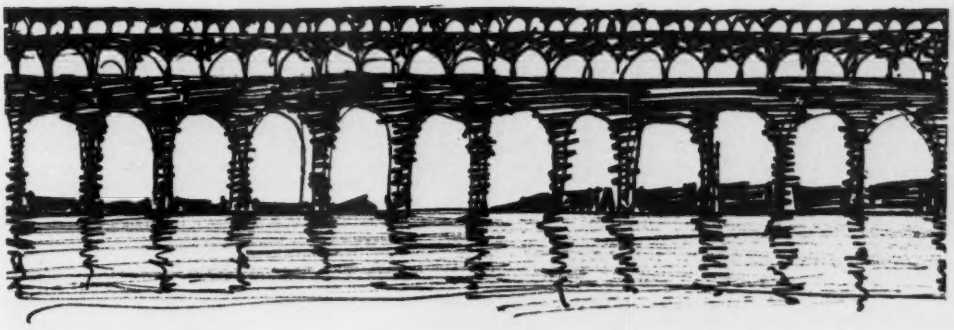
All these types of performance might be carried out by individual members of the organization, or, at least in part, by the teams and facilities of the organization. In either case they would still be at their most primitive levels. They would lack the more complex facilities to be discussed below. Yet they would represent from their very beginnings a new level of autonomy. The highest type of selfhood of the organization would now reside in the channels carrying these new functions; their destruction would now imply both the loss of a distinct value and a clear diminution of autonomy, reducing it to an earlier and lower level.

An essential step in the production of novelty involved the matching of a new internal recombination by a new secondary symbol. The consideration of secondary symbols may now lead us to the problem of consciousness, and its possible meaning in the performance of organizations.

Consciousness in an organization may be viewed as the attachment of secondary symbols to some of the primary messages moving through the systems. Such secondary symbols are symbols about "primary" messages or symbols (*i.e.*, messages or symbols originating in the outside world). They are fed back into the memory facilities, or directly into the determination of the behavior of the organization. In either case they may change the statistical weight of the primary messages and change significantly the overall performance of the system. The result may be greater accuracy in the treatment of information from within the organization or from the outside world, or it may be the very opposite. Consciousness may be "false consciousness," grossly misrepresenting the character or performance of the organization to itself and to its members.

This change may be particularly conspicuous, if secondary symbols of consciousness become attached to operating values which hitherto merely had been implicit in the configuration of the system. Now some of these values become conscious for us. They may now be confronted with other values in the system, they may be criticized and tested and, as a result, be either reinforced or modified. As a further result, the set of operating values as a whole may then become more consistent and effective.

Consciousness, clearly, seems a higher function of control, even though it may sometimes take up critically scarce facilities or impose critical delays, so that the "unconscious" or "intuitive" performance will appear swifter or more accurate. As it is a higher function, consciousness itself may be considered a value, and the highest type of selfhood of an organization would reside in the particular set of communications facilities in



which the secondary symbols of consciousness are produced, carried, and processed.

5. Will and the Problem of Commitment

If memories and values can be tested by consciousness, they can also be deliberately frozen. Here the problems of consciousness touch upon those of will.

We may speak of will in the case of an organization, wherever a decision has been taken in the treatment of information within the organization, so as to assure preponderance to predecision data over postdecision ones. By a decision is meant here a significant physical change in the connections or performance characteristics of some channels of communication. Preponderance for predecision data means assigning greater statistical weight, or giving priority treatment, to earlier incoming information and recalled memories, and to those of their implications which may be subsequently worked out without upsetting the main trend of the original data from which they were derived. Earlier data contradicting this main trend are forgotten or repressed, and so are, even more easily, contradictory new data coming in after the "decision has hardened." The deadlines of newspapers, the freezing of designs for industrial mass production, the carrying out of battle plans, are examples of the problems involved.

The advantage of "will," or of a temporary freezing of a given pattern of treating information and allocating material facilities, is in the gains of the ability of the organization to commit its resources. Frozen decisions may save time; frozen patterns of behavior sometimes can be applied immediately. The more time is at a premium and resources are scarce, the more important it may be to commit them fast enough and soon enough to bring at least a chance of success, rather than let everything be dissipated in a long weighing of alternatives "cast o'er with the pale sickliness of thought," until they "lose the name of action."

Yet the gain is temporary, and the price of perpetual "emergency behavior," like that of permanent "emergency government," is high. Frozen designs do not make for the best designs; "crash priorities" are a poor way of allocating resources; the wailing sirens and the racing fire truck do not make for smooth traffic flow. "Will power," "total commitment," "iron firmness," while they may stand for important policies at certain times, all are yet at the same time poetic metaphors for an ominous capacity: the capacity not to learn beyond quite narrow limits. An organization following such policies for long, becomes not more self-steering or autonomous, but less: it may become the prisoner of its own past. Anxious not to let their organization drift with the current of the present, its leaders have tried to turn it into a bullet or torpedo fired from its past. This may produce a gain in momentum; but, in the long run, it may produce a far more critical loss of selfhood and autonomy.

6. Learning Capacity and the Range of Outside Contacts

In the short run, the ability of a social group or organization to endure depends perhaps on its cohesion and on its ability to maintain itself under the conditions in which it finds itself. In the long run, however, its ability to survive may rather depend on its capacity for adapting itself to a wide range of changes in its environment, and for developing new patterns of behavior, so as to adapt the environment to its own needs. Organization and environment might then, in this event, continue to transform each other in a sequence of steps in which the initiative might lie as often, or probably more often, with the organization as with the environment.

The particular capacity required of the organization for such an outcome may be called its capacity for learning. We may say that learning has occurred in a human being, or in an animal, or in a social organization, when a previously consistent type of output, or response, to a particular kind of input, or "stimulus," is replaced by another response without any significant change in the stimulus. Learning, in this sense, always involves the rearrangement of some physical facilities within the learning system. The facilities so rearranged may be distributions of matter or of energy. They may be states of nerve cells, or connections between them, in the body of a man or animal. They may be physical facilities at the disposal of a city, an army, a nation, or any other social organization, or they may be configurations of communications channels within any such organization.

The learning performance in each of these cases can then be measured in two ways. First, it can be measured in terms of the difference between the prelearning output of the organism or the organization as against the new output, under comparable input conditions, after learning has occurred. How much better does the football team play after training than before? How does the military performance of seasoned troops compare to that of untrained troops? How does the export-import balance of a recently industrialized country compare with its export-import balance just before industrialization?

This method of measuring the learning performance of an organization directly in terms of the changes in its relevant output-input balance over time, has the disadvantage that we cannot tell for sure whether the

newly "learned" performance, *i.e.* the new input-output relationship, will continue into the future. We may then resort to the second method of measuring learning performance, this time more indirectly, in terms of internal structural changes. While this second method alone and in itself could not be trusted, the two methods together, where both can be applied, should give more dependable results than either method could give in isolation. As their inner structure often can be inspected, social groups and organizations might form a class of cases to which this combination of the two methods might well be applicable.

If we can measure learning performance in the past, we should be able to predict or estimate probable learning performance for certain cases in the future. Here we may take as our goal an estimate of the probable ensemble of the adaptations or learning performances of an organization over a whole range of different future "challenges" or learning situations. This is again our concept of learning capacity, and we can say of it that the learning capacity of a social group or organization is in some ways related to, or proportional to, the uncommitted resources of the organization.

It should be noted that the learning capacity we are discussing here is that of the organization as a whole, as distinct from that of its individual members. The learning capacity of all the individual automobile drivers in a traffic jam could be reckoned in terms of the changes in the equipment of their cars, or the improvement in their personal driving habits, and their aggregate effect on traffic flow. The learning capacity of a city or a traffic organization as a whole, on the other hand, could be estimated in the terms of the rearrangement of the streets, lanes, intersections, underpasses, road signs, and traffic lights, all of which together determine a large part of the overall patterns of traffic flow in the entire area.

We have said that the learning capacity of an entire group or organization, that is, the range and power of its effective internal rearrangements, can be measured to some extent by the number and kind of its uncommitted resources. Such resources need not be idle, but they must be capable of being reassigned more or less readily from their present functions.

There is a qualitative element in learning capacity, as it depends not only on the amount of uncommitted resources but also on their configurations. Yet, as learning capacity consists in an overall performance, a particular configuration of internal elements can be replaced, in many cases, by some functionally equivalent configuration of others. This is the more probable, the richer the range of available rearrangements, and thus, again, the greater the amount of uncommitted resources, and of facilities for their quick and varied recommitment.

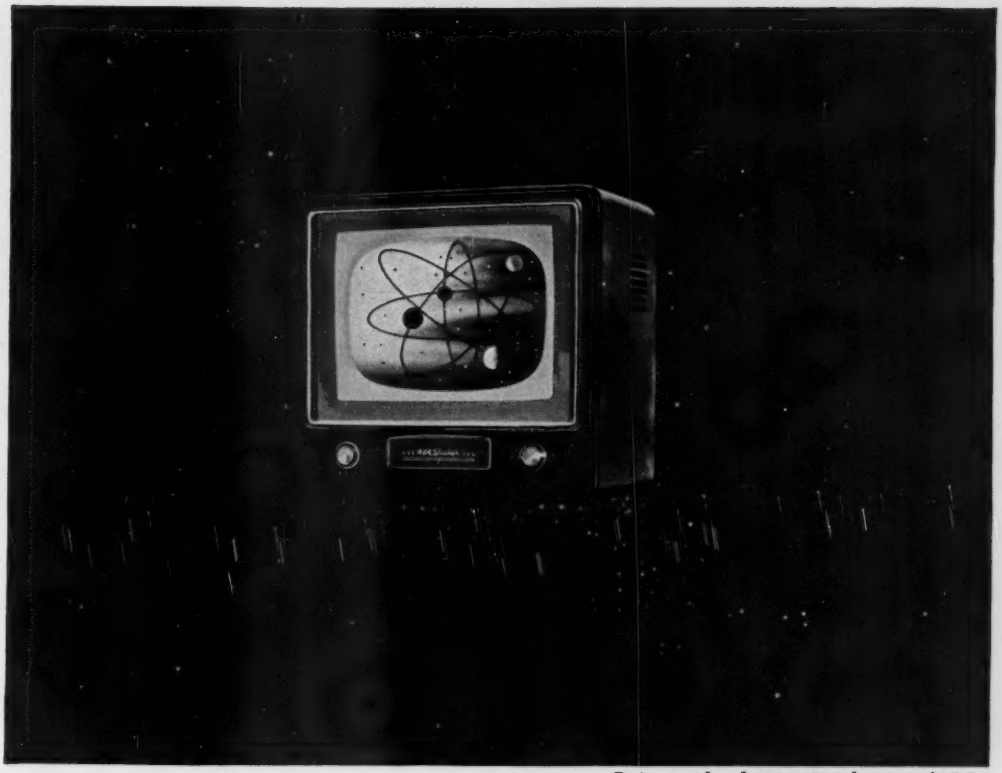
Estimates of the learning capacity of an organization for some time in the future can again be derived from our two methods. First, it can be estimated by extrapolating the results of outside tests of the overall performance of the organization: the learning capacity of rats is tested in a maze, and that of armies is tested in battle. Secondly, the learning of an organization can be estimated from an analysis of its inner structure. The greater learning capacity of rats compared to frogs can be predicted from the greater size and complexity of the rat's nervous system; or the greater learning capacity or adaptability of one army rather than another, can be predicted if, other things being equal, it has greater facilities for communication and transport and a greater "operational reserve" of uncommitted manpower and equipment. As overall performance tests are cheap in rats, but expensive in armies, or in the defense of cities against atom bombs, the prediction of probable learning capacity from structural analysis and the suggestions for probable improvements by the same method, may have considerable practical importance.

Of the many kinds of possible inner structural rearrangement which learning capacity includes, one kind is perhaps in the long run of particular significance. It is the capacity of an organization so to rearrange its channels and resources that it gains access to new kinds of *input*, or in human terms, to new dimensions of experience. To learn to open up new contacts with its environment — indeed to discover new series of environments — this is perhaps crucial in the long run development of an organization. Simple physical growth has often been described in terms of metabolism: the capacity to draw additional amounts of matter and energy out of the surroundings of an organism or organization, and to use these to enlarge the physical resources at its disposal. Now we may perhaps add some notion of another, though related, type of growth: an increase in the range and volume of an organization's intake of information, and its internal feedback on the intake arrangements of the organization, so as to produce a further widening of the flow of new experiences, a further increase in the effective intake facilities of the organization.

A third type of learning capacity might remind us of certain patterns of growth suggested by A. J. Toynbee. They would be kinds of learning capacity which involve such inner rearrangements of facilities as would increase an organization's capacity for recommitting its resources in the future. They might imply an increase in the number of internal recombinations possible in the allocation of physical facilities and even more so in the processing of information. They might finally involve an increase in the number and effectiveness of higher order feedbacks, including the facilities for self-steering, for consciousness, for novelty, and for initiative. The ensemble of learning capacities of this third kind might then well resemble the type of growth which A. J. Toynbee characterized as an "increase in self-determination," and which he considered to be characteristically accompanied by a transference of activities from the external to the internal environment, and by further stages of inner transformation.

Many of these types of learning capacity may be unimportant for many social organizations which have been set up for limited purposes and for a limited time. But these higher types of learning capacity may well be critically important for those social groups or social organizations which are intended by their members to continue to function, despite large changes in the environment and over long periods of time. Our community, our country, our nation, our church, philosophy, or denomination, and our common family of all mankind, all these we know to have endured for decades, centuries, or millennia, and we may intend them to endure for still much longer in the future. We may wish that they shall retain their separate distinctness, their identity. Yet such is perhaps a paradox of persistence and of growth, that those groups or organizations may well have the best chances for ultimate survival, which have learned to keep themselves open to ever new contacts with a universe which we may still believe to be inexhaustible.

In the next issue of T. E. N. *Professor Deutsch will discuss "Freedom and Authority as Aspects of Organization."*



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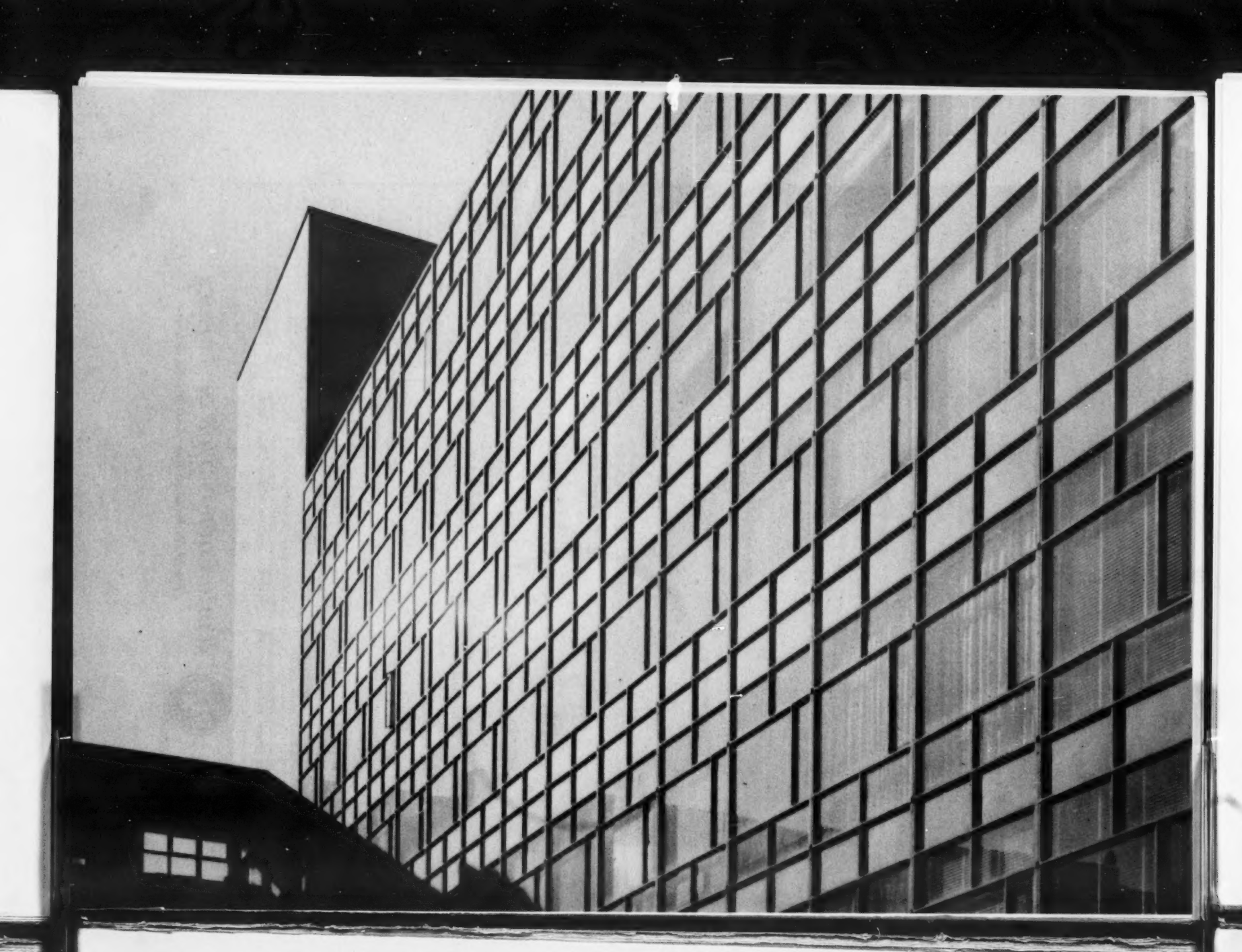

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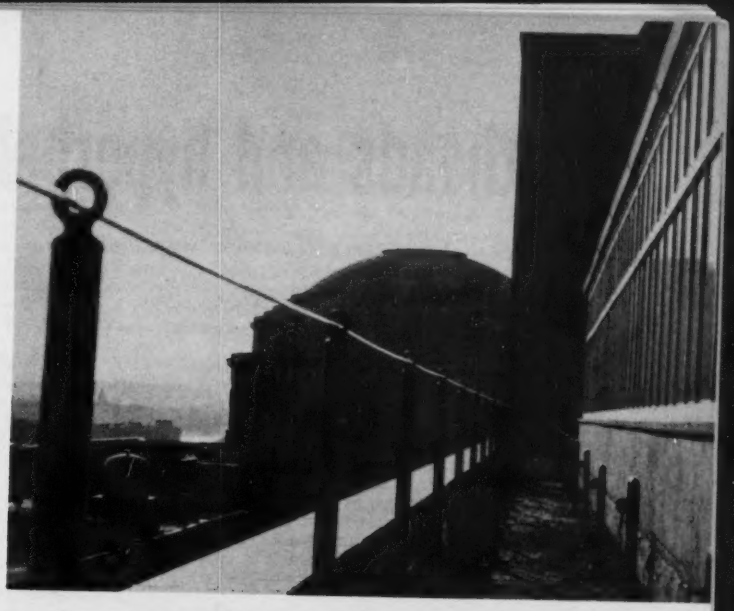

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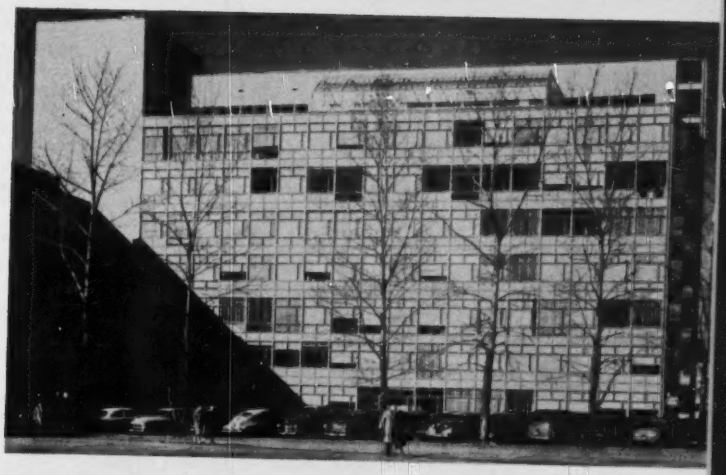

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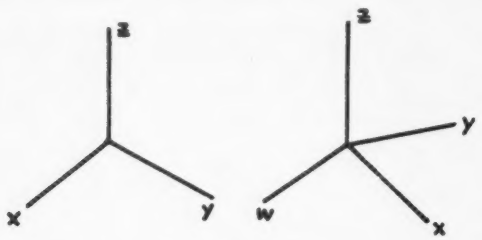
flatheads and hyperbeings

Exploitation of Dimensional Extrapolation

By D. F. Shrader, '58

What is the fourth dimension? This question may be answered in two ways. It may be considered either as a mathematical abstraction or as a real, physically existent, entity. The former answer will satisfy the mathematician while the latter is the answer sought by the spiritualist, theologian or anyone else who delves into metaphysics. The mathematician is content to ignore hyperspace as far as a physical existence is concerned. He realizes that either a proof or disproof is impossible and useless to his science. Whether or not a physical fourth dimension exists has no effect upon the



existence of a mathematical fourth dimension. The supernaturalist also realizes, and smugly so, that a disproof is impossible, but he does not give up attempts to find a pseudo-scientific proof. No one can definitely disprove his invented metaphysical phenomena to him if he can explain them with something as vague and intangible as hyperspace. Thus, with the aid of an added dimension, the spiritualist can explain the passing of bodies through solid substances, and the theologian can locate hell.

A mathematical formulation of a physical hyperspace can be derived if only it is assumed to exist. Then all the mathematics and geometry of hyperspace may be derived through analogy to one, two and three dimensional arrangements.

In discussing hyperspace, which can only be done through analogy to lower dimensional domains, it is always useful to imagine the existence of two and four dimensional beings, that is, an animal that lives in two dimensions and knows of no more than two dimensions, and an animal that lives in four dimensions and can see and move about through four dimensions. In this article, they will be called, respectively, the flathead and the hyperbeing.

The fourth dimension can be represented on a two dimensional paper surface just as easily as can the third dimension. Since the surface contains only two dimensions, a third dimension is represented by drawing a line and imagining that it has depth. This is easy since the eye is accustomed to solid objects and can visualize flat representations as solid. Similarly, a fourth dimension can be represented on a two dimensional surface by drawing a line and imagining that it has depth, but a depth which is different from the three dimensional depth, and one which is impossible to visualize since the eye has never and can never see a four dimensional figure.

Diagram *xyz* of figure 1 represents a three dimensional framework. Of course, man can visualize its depth, but the flathead is incapable of doing so since his mind as well as his body and eyes is restricted to two dimensions. Diagram *wxyz* represents a four dimensional framework. Here, man has the same restrictions as the flathead has with three dimensions. Man is limited to three dimensions and cannot visualize the fourth. But the hyperbeing is one dimension further advanced than man, and he sees the framework in its three dimensional projection as an actual representation of four dimensions, similar to the four dimensions he is capable of conceiving in hyperspace.

As the triangle and tetrahedron are the simplest figures in their respective dimensional domains, the pentahedroid is the simplest figure of hyperspace. The triangle is evolved from the two dimensional line which has two vertices by choosing a third vertex which does not lie in the same dimension as the first two, but which lies in a second dimension, and then connecting all

vertices with lines. The tetrahedron is evolved from the triangle by choosing a fourth vertex which does not lie in the same two dimensions as the first three, but which lies in a third dimension, and connecting all vertices with lines. Analogously, the four dimensional pentahedroid is evolved from the tetrahedron by choosing a fifth vertex which does not lie in the same three dimensions as the first four, but in a fourth dimension, and connecting all vertices with lines. The tetrahedron appears real to man but not to the flatbeing, while the pentahedroid appears real to the hyperbeing but not to man.

The four dimensional analogy to the square and the cube is the tesseract. The square is generated from the line by passing it into a second dimension perpendicular to its direction. The line generates a plane and is repeated at the opposite side of the square. Each vertex generates a line and is repeated at the opposite side of the square. The cube is generated from the square by passing it into a third dimension, perpendicular to its plane, that is, to the direction of its composite lines. The plane of the square generates a cell and is repeated at the opposite side of the cube. Again each line generates a plane and is repeated at the opposite side of the cube, and each vertex generates a line and is repeated at the opposite side of the cube. The tesseract is generated from the cube by passing it into a fourth dimension, perpendicular to its space, that is, to all of its lines. The cell of the cube generates a hypercell and is repeated at the opposite side of the tesseract. The rules for the generation of vertices, planes and cells are the same as those of the line, square and cube. Stated in formulas, where V denotes a vertex, E a line or edge, F a plane or face, C a cell, and H a hypercell, and the prime ($'$) denotes an added dimension, they are:

$$V' = 2V$$
$$E' = 2E + V$$
$$F' = 2F + E$$
$$C' = 2C + F$$

and analogously, continuing on into the fifth dimension:

$$H' = 2H + C$$

The hypertesseract of five dimensions is parallel to the square, cube and tesseract of two, three and four dimensions, and is formed by generating a tesseract into a fifth dimension, perpendicular to its hyperspace, that is, to all of its lines.

		Dimension						
		0	1	2	3	4	5	6
Vertex	V	1	2	4	8	16	32	64
Edge	E		1	4	12	32	80	192
Face	F			1	6	24	80	240
Cell	C				1	8	40	160
Hypercell	H					1	10	60
Hyperhypercell	J						1	12
Etc.	K							1

TABLE OF DIMENSIONS WITH CORRESPONDING COMPONENTS FOR POINT, LINE, SQUARE, TESSERACT, HYPERTESSERACT, ETC.

A more complete analysis of hyperspace reveals that Euler's formula for solid figures:

$$F + V = E + 2$$

has its analogy for hypersolid figures:

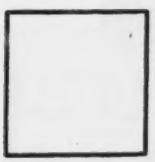
$$F + V = C + E$$

The cell of the cube in figure 3 appears cubic to man, but the cells of the tesseract do not appear cubic. They do appear cubic to the hyperbeing, however, and the inability of man to visualize the cells as cubic is similar to the inability of the flathead to visualize all of the faces of a cube as squares. Some of the faces of the cube appear as parallelograms to the flatbeing, while some of the cells of the tesseract appear as parallelepipeds to man. Furthermore, the hyperbeing does not visualize all of the hypercells of the hypertesseract as tesseracts, but it remains for a being of five dimensions to see them as such.

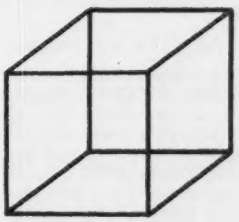
Corresponding to the five Platonic solids, there are only five regular hypersolids. Besides the regular pentahedroid and tesseract, there exist the regular hexadecahedroid ($V = 8$, $E = 24$, $F = 32$, $C = 16$), a 24-hedroid ($V = 24$, $E = 96$, $F = 96$, $C = 24$), and a 600-hedroid, the hexacosioihedroid ($V = 120$, $E = 720$, $F = 1200$, $C = 600$).

Analogous to the circle and sphere is the hyper-

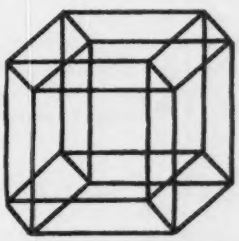
Line



Square



Cube



Tesseract

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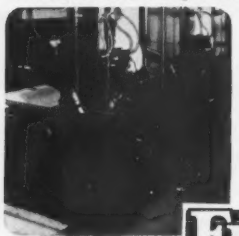

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sphere. It is a four dimensional figure, the locus of whose points lies at a constant distance from its center. Its formula is:

$$w^2 + x^2 + y^2 + z^2 = \text{constant} = a^2$$

Its content, or hypervolume, can be found by integration with a method similar to that used in finding the area of a circle or the volume of a sphere. Just as a plane passed through a sphere intersects it along the circumference of a circle, a space of fourth dimensional width, dw, passed through a hypersphere intersects it along the surface of a sphere. The volume of the sphere is:

$$V = \frac{4}{3}\pi r^3$$

where:

$$x^2 + y^2 + z^2 = r^2$$

Then:

$$C = \int_{-a}^{+a} \frac{4}{3}\pi r^3 dw = \frac{8}{3}\pi \int_0^a (a^2 - w^2)^{\frac{3}{2}} dw$$

Let: $w = a \sin\theta$

Then:

$$C = \frac{8\pi a^4}{3}\int_0^{\frac{\pi}{2}} \cos^4\theta d\theta = \frac{\pi^2 a^4}{2}$$

The volume of the hypersphere, or what corresponds to the area of a sphere, is found by integration to be:

$$V = 2\pi^2 a^3$$

The size of a figure of locus r = constant in space of $2n$ dimensions is:

$$S = \frac{\pi}{1}r^2 \cdot \frac{\pi}{2}r^2 \cdots \frac{\pi}{n}r^2$$

The size of a figure of locus r = constant in space of $2n - 1$ dimensions is:

$$S = \frac{1}{\pi r} \cdot \frac{2\pi}{1}r^2 \cdot \frac{2\pi}{3}r^2 \cdots \frac{2\pi}{2n-1}r^2$$

Note that in the circle, sphere and hypersphere, the ratios of the area to the circumference, the volume to the area and the content to the volume are:

Circle	$\frac{\text{Area}}{\text{Circumference}}$	$= \frac{\pi r^2}{2\pi r}$	$= \frac{r}{2}$
Sphere	$\frac{\text{Volume}}{\text{Area}}$	$= \frac{\frac{4}{3}\pi r^3}{4\pi r^2}$	$= \frac{r}{3}$
Hypersphere	$\frac{\text{content}}{\text{volume}}$	$= \frac{\frac{1}{2}\pi^2 r^4}{2\pi^2 r^3}$	$= \frac{r}{4}$

For n dimensions, the ratio is r/n.

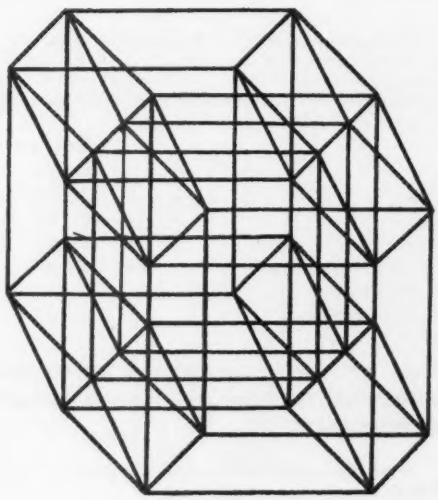
Thus the hypercontent of a hyperhypersphere of $n = 5$ dimensions is:

$$\frac{1}{\pi r} \cdot \frac{2\pi}{1}r^2 \cdot \frac{2\pi}{3}r^2 \cdot \frac{2\pi}{5}r^2 = \frac{8\pi^2}{15}r^5$$

and its content is:

$$\frac{\frac{8\pi}{15}r^5}{r/5} = \frac{8\pi^2}{3}r^4$$

The hypertesseract.



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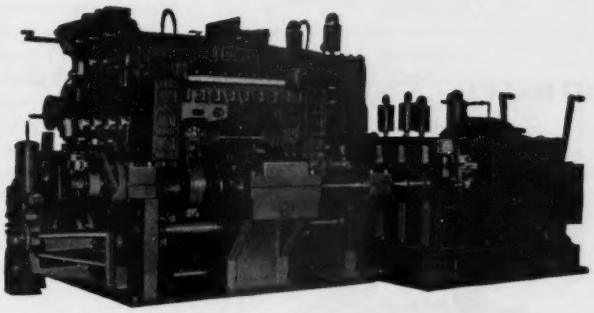

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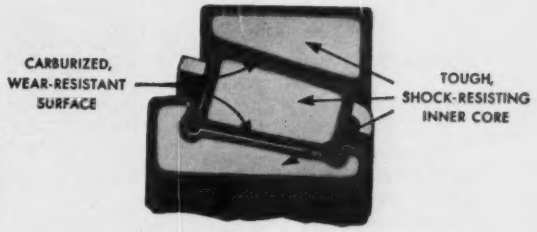

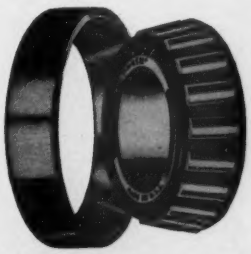

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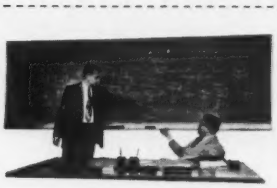

The complexity of modern air defense—extreme aircraft speeds, highly complex weapons, new combat strategies, the advanced state of today's technology—poses serious problems for the scientist and engineer.

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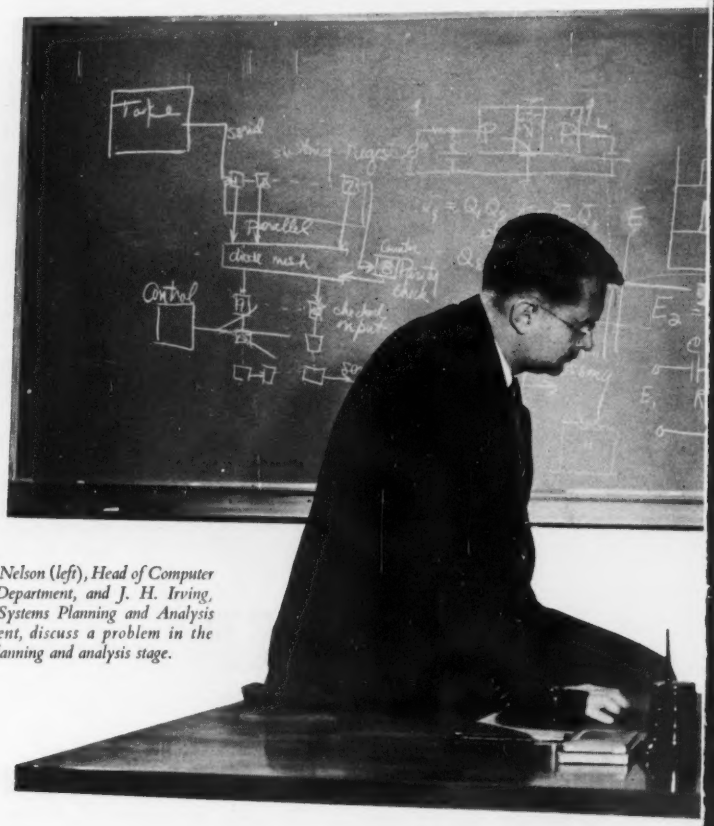

Dr. E. C. Nelson (left), Head of Computer Systems Department, and J. H. Irving, Head of Systems Planning and Analysis Department, discuss a problem in the systems planning and analysis stage.

each problem is attacked basically, beginning with systems planning and analysis. This consists of an exhaustive examination of the requirements of a problem, together with an evaluation of the best means for satisfying these requirements. The objective is to design the simplest possible mechanization consistent with a superior performance.

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from the editor's notebook

Help Wanted for One Ailing Goose

The United States has a goose which can produce golden fruit in abundance, yet some honest citizens are bent on throttling the rare bird. Our "goose" is covered with ivy walls rather than feathers; she is composed of the many universities and research institutions which are making great scientific advances. The staffs of these schools are continuously hampered by useless and annoying security regulations which could have been devised by the Kremlin to thwart our scientific progress.

Obviously there are some scientists who have access to information which is vital to our national security. These individuals should, of course, be investigated thoroughly before being given responsibility. Any key scientist whose loyalty is open in any way to suspicion should be kept in one of the many jobs where little secrecy is needed. By all means we should try to keep our national scientific establishment as secure as possible.

Today, however, we have gone too far. For instance, one damaging and useless attempt at security is our present visa policy. The United States places domestic and foreign scientists alike in the humiliating and infuriating position of being forced to practically beg for permission to enter or leave the country for even a few weeks. Each entering scientist must submit to a loyalty test which would never find communists but which has insulted distinguished visitors to the point of refusing to answer the questions. Sometimes a foreigner cannot attend an important meeting held in the United States because his application for a visa is not acted upon until weeks after the meeting. A few such experiences have made countries with more enlightened visa policies (i.e., England) the site of international scientific gatherings. Now American scientists have to submit to red tape and arbitrary action on their own passports.

It is difficult to see how a visiting scientist could filch any information of any security value. Certainly classified information is not discussed openly in meetings. Furthermore, the proceedings of such gatherings are usually published in journals. The distasteful impression which our visa policy leaves on foreign scientists and the restraint of exchange of scientific information which it entails are far more harmful than the espionage a visitor could perpetrate in two weeks' stay in our country.

Our scientists are also harassed from within our country. We must have investigations to try to ferret out "subversive influences" in our universities. Probably the average person suspects that college faculties, which occasionally come forth with ideas which differ from the accepted standard of the country, tend to be radical or communistic. A professor now has to think twice before stating his views on politics unless he is safely within the fold of either of the two major parties. The worst aspect of the situation is that much of the frantic seeking for communists comes from what should be the steadiest element in our society: the administrations of various academic institutions. Many schools have required loyalty oaths of their faculties; no doubt each communist jumped at the chance to proclaim, "Yes, I am a communist spy intent on enslaving you capitalistic warmongers!" Shades of Daddy Warbucks! What can we expect? I am gratified that Tech did not consider Dirk Struik to be a Russian agent because he preferred Marxism to capitalism and said so.

I only wish that our security program could be made to foster the national interest as a whole rather than trying to make headlines in newspapers or keeping good men out.

J. M.

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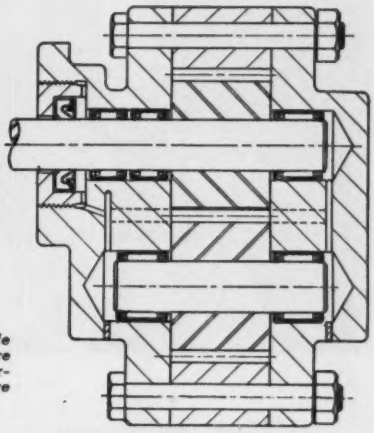

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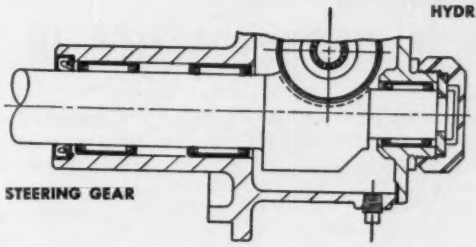

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on the moral obligation of the scientist

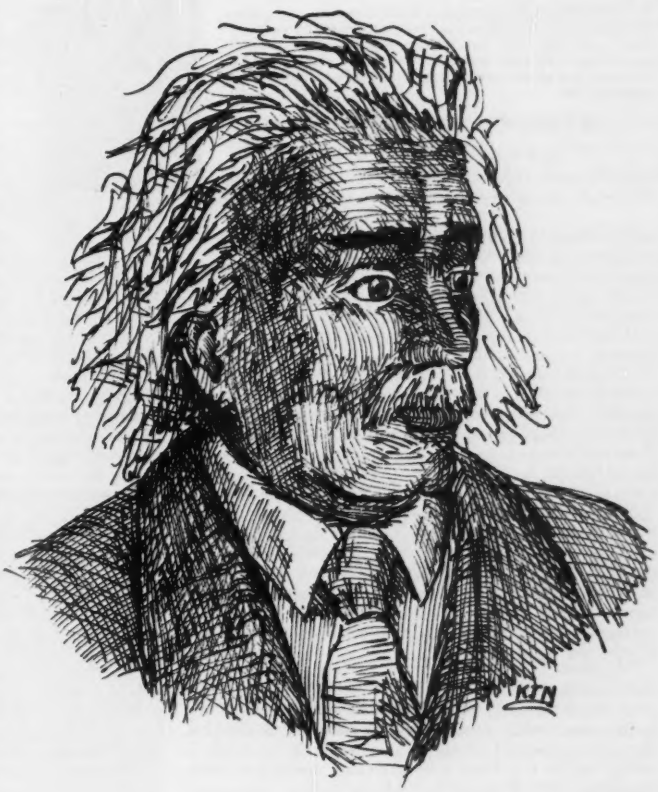
By Albert Einstein

Reprinted from the Society for Social Responsibility in Science "Newsletter"

Let me first thank you most sincerely for your kindness in inviting me to attend the meeting of the "Society for the Advancement of Science." I should gladly have accepted the invitation if my health had permitted me to do so. All I can do under the circumstances is to address you briefly from my home across the ocean. In doing so I am under no illusion that I have something to say which would actually enlarge your insight and understanding. However, we are living in a period of such great external and internal insecurity and with such a lack of firm objectives that the mere confession of our convictions may be significant even if these convictions, as all value judgments, cannot be proven through logical deduction.

There arises at once the question: should we consider the search for truth — or, more modestly expressed, our efforts to understand the knowable universe through constructive logical thought — as an autonomous objective of our work? Or should our search for truth be subordinated to some other objective, for example to a "practical" one? This question cannot be decided on a logical basis. The decision, however, will have considerable influence upon our thinking and our moral judgment, provided that it is born out of deep and unshakeable conviction. Let me then make a confession: for myself, the struggle to gain more insight and understanding is one of those independent objectives without which a thinking individual would find it impossible to have a conscious, positive attitude toward life.

It is the very essence of our striving for understanding that on the one hand it attempts to encompass the great and complex variety of



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man's experience, and that on the other, it looks for simplicity and economy in the basic assumptions. The belief that these two objectives can exist side by side is, in view of the primitive state of our scientific knowledge, a matter of faith. Without such faith I could not have a strong and unshakeable conviction about the independent value knowledge.

This, in a sense, religious attitude of man engaged in scientific work has some influence upon his whole personality. For apart from the knowledge which is offered by accumulated experience and from the rules of logical thinking, there exists in principle for the man in science no authority whose decisions and statements could have in themselves a claim to "Truth." This leads to the paradoxical situation that a person who devotes all his strength to objective matters will develop, from a social point of view, into an extreme individualist who, at least in principle, has faith in nothing but his own judgment. It is quite possible to assert that intellectual individualism and the thirst for scientific knowledge emerged simultaneously in history and have remained inseparable ever since.

Someone may suggest that the man of science as sketched in these sentences is no more than an abstraction which actually does not exist in this world, not unlike the *homo oeconomicus* of classical economics. However, it seems to me that science as we know it today could not have emerged and could not have remained alive if many individuals, during many centuries, had not come very close to the ideal.

Of course not everybody who has learned to use tools and methods which directly or indirectly appear to be "scientific" is to me a man of science. I refer only to those individuals in whom the scientific mentality is truly alive.

What, then, is the position of today's man of science as a member of society? He obviously is rather proud of the fact that the work of scientists has helped to change radically the economic life of men by almost completely eliminating muscular work. He is distressed by the fact that the results of his scientific work have created a threat to mankind since they have fallen into the hands of morally blind exponents of political power. He is conscious of the fact that technological methods, made possible by his work, have led to a concentration of economic and also of political power in the hands of small minorities which have come to dominate completely the lives of the masses of people, who appear more and more amorphous. But even worse: the concentration of economic and political power in the hands of a few has not only made the man of science dependent economically, it also threatens his independence from within; the shrewd methods of intellectual and psychic influences which it brings to bear will prevent the development of independent personalities.

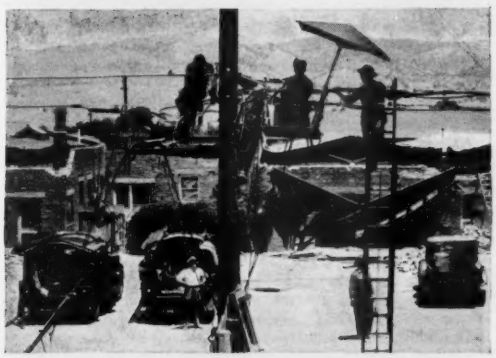
Thus the man of science, as we can observe with our own eyes, suffers a truly tragic fate. Striving in great sincerity for clarity and inner independence, he himself, through his sheer superhuman efforts, has machined the tools which are being used to make him a slave and to destroy him also from within. He cannot escape being muzzled by those who have political power in their hands. As a soldier he is forced to sacrifice his own life and to destroy the lives of others even when he is convinced of the absurdity of such sacrifices. He is fully aware of the fact that universal destruction is unavoidable since historical development has led to the concentration of all economic, political and military power in the hands of national states. He also realizes that mankind can only be saved if a super-national system, based on law, were created to eliminate for all time the methods of brute force. However, the man of science has slipped so much that he accepts the slavery inflicted upon him by national states as his inevitable fate. He even degrades himself to such an extent that he helps obediently in the perfection of the means for the general destruction of mankind.

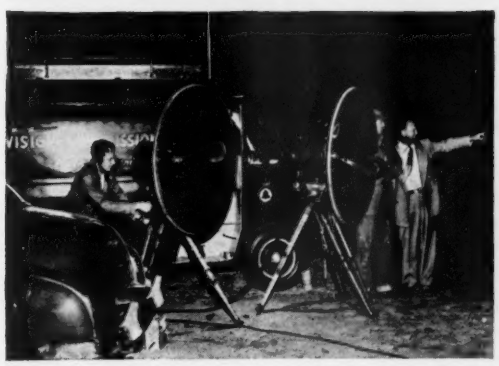
Is there really no escape for the man of science? Must he really tolerate and suffer all these indignities?

Is the time gone forever when, aroused by his inner freedom and the independence of his thinking and his work, he had a chance of enlightening and enriching the lives of his fellow-human beings? In placing his work too much on an intellectual basis has he not forgotten about his responsibility and dignity? My answer is: while it is true that an inherently free and scrupulous person may be destroyed, such an individual can never be enslaved or used as a blind tool.

If the man of science of our day could find the time and courage to think honestly and critically over his situation and the tasks before him and if he would act accordingly, the possibilities for a sensible and satisfactory solution of the present dangerous international situation would be considerably improved.

earthquake!





Precisely at 4:50 A. M. in the predawn darkness of last July 21, the most severe California earthquake since 1906 struck the small town of Tehachapi.

Walls were collapsing, buildings were folding. The town's telephone office shook to its foundation and the lights went out. But the night operator remained at her switchboard until it went dead. Main cables to the telephone office were pulled to the ground when a nearby wall caved in.

This was at 4:50 A. M.

At 8:30 A. M., less than 4 hours later, telephone men had reestablished 3 circuits on the edge of town (top picture). Outdoor offices were set up for Red Cross and other emergency workers.

Repairs to the damaged main cable and other equipment were rushed (center picture). By late afternoon the central office switchboard was working. Tehachapi residents were able to make calls to friends and relatives concerned about their safety.

By 9 P. M., two TV stations were sending live telecasts of the damage to Southern California viewers (bottom picture). Telephone men had established a 4-jump radio-relay station in less than 12 hours.

It was a typical disaster—brutal and unannounced. But telephone men were prepared. They quickly restored communication when it was needed most. In so doing, they demonstrated the resourcefulness and technical skill which telephone companies ask of their engineers.

For qualified engineering graduates of this caliber, there are opportunities in the telephone companies. Your college placement officer can give you details. Or write to American Telephone & Telegraph Company, College Relations Section, 195 Broadway, New York 7, N. Y., for the booklet, "Looking Ahead."

BELL TELEPHONE SYSTEM

switching circuit techniques

Part II: Sequential Relay Circuits

By Howard J. Simmons, '54

In part I[1] of this series we dealt with the design of systems of relays which, for each set of input conditions, yielded an output. The input was expressed in terms of certain contacts, on several relays or switches, being opened or closed. The output was expressed in the form of an open or closed circuit. In practical applications the closed circuit would result in the lighting of a lamp, the starting of a motor, or the connection of the relay system into another relay circuit. For a given output condition to exist at a given moment it was only necessary that the corresponding input conditions exist at that *same* moment. The important thing to remember about the circuits developed in part I is that how one arrived at the input was of no consequence as far as the output of the system was concerned. It was the combination of the existing relay and switch conditions, rather than the sequence of conditions leading up to that combination, that determined the output. For this reason such circuits are called combinational circuits. Combinational circuits suffer from a complete and continuing case of amnesia. In many applications, however, the order in which relays and switches are operated is as important as the identity of the relays or switches. The telephone dial system is a good example of just such a case. Circuits which are capable of detecting the time ordering of input conditions are called sequential switching circuits.

Our problem is to determine just how a sequential circuit might be designed. You will recall that in part I it was possible to simplify our circuit diagrams by eliminating the drawing, and hence the consideration, of the electromagnet. In the discussion that followed no mention was made of how one was to close the armature of the relay. In fact, one could have done it in any way he saw fit. A small amount of reflection will reveal that switching algebra and logic could be applied to ordinary mechanical switches. One might ask then if there is any value at all in the use of electromagnetic switches. You will recall that early in part I various control paths by which one switch might control another were introduced. Those readers requiring a detailed explanation of how these control paths operate may refer to part I. The drawings of these control paths appear again in figures 8 and 9. It was in the development of the control paths that the use of electromagnetic switches proved convenient but not indispensable. The switches in a combinational circuit were completely independent of each other. The position of any switch depended only on the particular set of input conditions imposed. Such switches or relays are called primary relative to the system. A switch or relay whose state is dependent on the position of some other switch or relay is called a secondary circuit element relative to the second switch or relay. Thus, in figures 8 and 9 switches A and B are primary relative to the system, and relay X is secondary relative to switches A and B. We see that the inclusion of secondary elements in our circuit might enable us to give our system a memory that is capable of directing its future actions. The memory circuits are shown in figures 8 and 9. We shall exploit these circuits along with the immediate action circuits in the development of a sequential system.

There are several possible methods of representing a sequential circuit on paper. A complete drawing of the circuit, accompanied by a detailed verbal description, is one of these. However, such drawings, even when only a few relays are used, are cumbersome, and it is difficult to follow the circuit actions. A more compact notation will be developed here.

The order in which we apply the input conditions is not the only point at which a consideration of time is necessary. From the instant that we apply current to the coil of the electromagnet to the first instant when a circuit is actually open or closed there is a time lapse. Again, when the current is stopped in the electromagnet, there is a time lapse until the spring returns the arma-

[1] "Switching Circuit Techniques" by Howard J. Simmons, in the December 1952 issue of *T. E. N.*

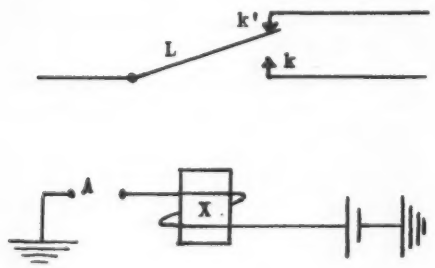


Figure 8-a. Immediate action by direct control.

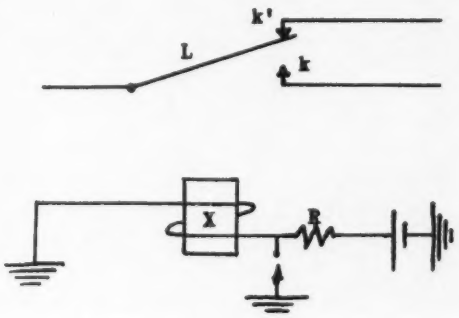


Figure 8-b. Immediate action by shunt control.

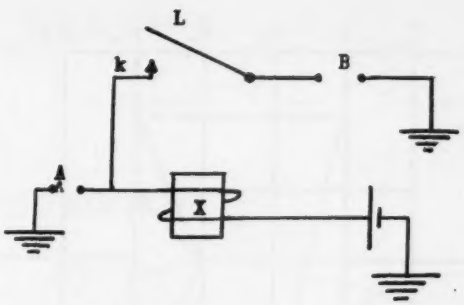


Figure 9-a. Memory by lock up.

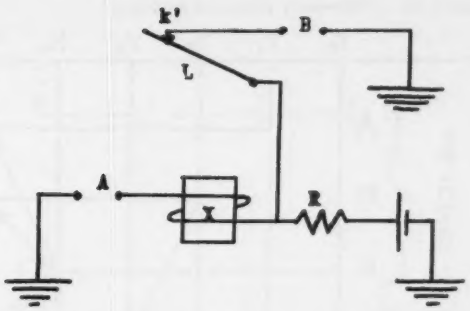


Figure 9-b. Memory by lock down.

ture to its normal position. These considerations lead us to distinguish between two terms previously used interchangeably. A relay is said to be *energized* if current sufficient to move its armature is flowing through the electromagnet, but the relay is not said to be *operated* unless the armature has completed its motion as a result of the energizing. It is also helpful to distinguish between the terms *de-energized* and *released*. Whenever a relay is not energized it is said to be *de-energized*, but a relay is not *released* until the spring has returned the armature to its normal position. The time difference between the instant a relay is energized and the instant it becomes operated is called its *operating time*. *Release time* is defined in a similar manner. We can how represent the sequential circuit in the following graphical manner. We list the letters representing the relays, switches, and output conditions in a vertical column. We establish a time scale along the horizontal. Any time a relay is *operated*, a switch closed, or an output condition in existence, we indicate this by drawing a heavy black line opposite the corresponding letter. To indicate that the opening or closing of one switch or relay has caused another circuit element to operate we use arrows. The arrows are to be drawn from the beginning of one horizontal line to the beginning of the other. The graphical representation of figure 9-a is given in figure 10. This representation is equivalent to the drawings and verbal descriptions used in part I. The interval T_0–T_1 is the time the system was in its normal state, T_1–T_2 is the period between the closure of B and the closure of A, T_2–T_3 is the operating time of relay X. T_3–T_4 is the time between the operation of X and the opening of A. T_4–T_5 is the time between the opening of A and the opening of B. T_5–T_6 is the release time of X. The fact that the intervals are drawn equal here is a matter of drawing convenience and has no circuit significance.

Rather than to give a general method for the design of sequential circuits, we will content ourselves with a single easy example, and merely indicate the extension of this simple situation to more complex problems. The simplest problem concerning a sequential circuit is that of designing a system capable of detecting the time ordering of two separate input conditions, each of which may be applied but once in any sequence. We phrase the problem in the following way. Operations are to be performed in order given.

Design a circuit such that:

closing switch A, then closing switch B, results in the lighting of lamp L_1;

or

closing switch B, then closing switch A, results in the lighting of lamp L_2.

We require that neither lamp be lit unless both A and B are closed. It is necessary that the system be returned to its original state merely by opening or closing an eraser switch E.

We first draw our sequence diagram, noting that all elements are secondary relative to the eraser switch E. The diagram is shown in figure 11. Our outputs are lamps L_1 and L_2. This diagram apparently represents our circuit, but this is not possible. The intervals T_3–T_4 and T_8–T_9 have the same circuit states but different outputs. We must find a way of making the system remember that the order of A and B was not the same in both cases, and, as a result, assume a different state in each case. One way (not the only way) of doing this is to introduce a secondary relay that is closed as a result of closing A before B, is not effected by closing B once A has been closed, and will not be effected by closing A once B has been closed. Clearly, there is no combinational circuit that will accomplish this. Assuming that we have developed such scheme of relays, we insert the required relay into our diagram. The resulting circuit diagram is shown in figure 12. We must now interpret our diagram in terms of a relay and switch circuit.

From the diagram, we know that in the interval T_3–T_4 the closing of A, B, and X must light L. From this we obtain branch 1 of our circuit (figure 13). The fact that closing A before B must close X (interval T_1–T_2) gives us branch 2-a. The requirement that closing B after A is closed must not affect X, and the closing of B before the closing of A must cause the closing of A

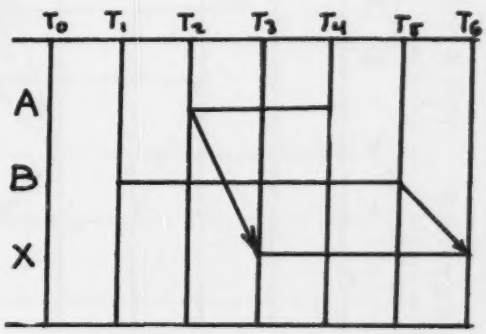
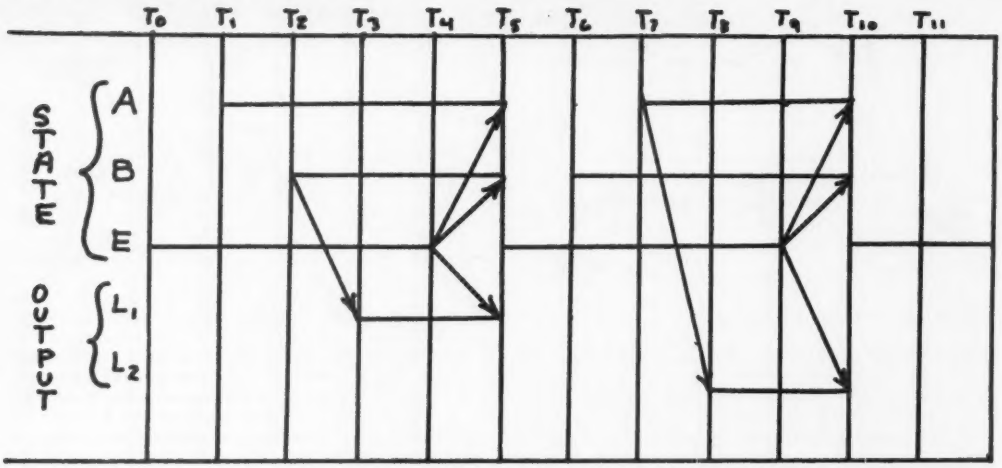


Figure 10. Graphical representation of circuit in figure 9-a.

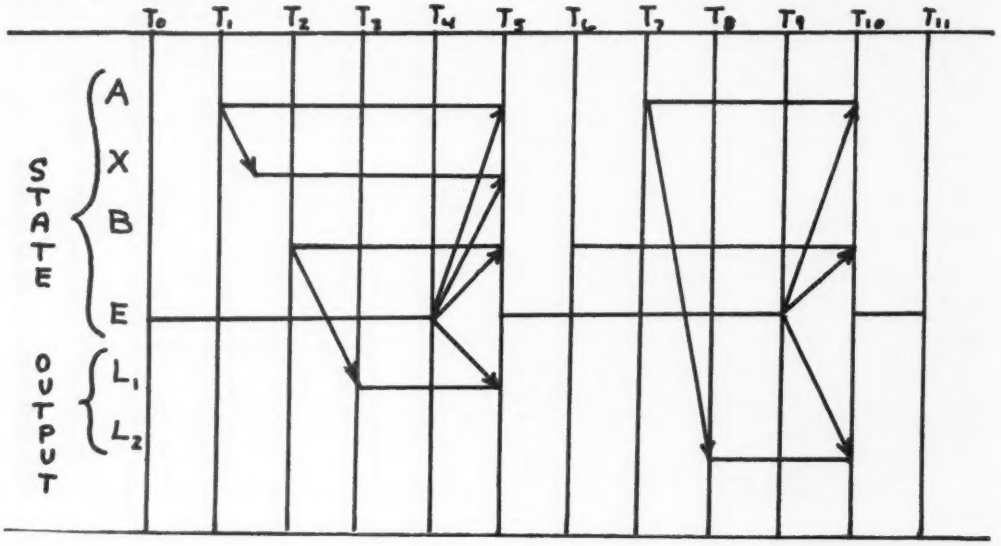
Figure 11. Preliminary sequence diagram.



have no effect on X (interval T_6–T_8) causes us to revise branch 2-a to obtain branch 2-b. You will note that we have used a lock-down memory circuit in branch 2-b. Finally, the condition that L_2 be lighted when A and B are closed, but X is open (interval T_8–T_9) gives us branch 3 of our circuit. If we now insert an eraser switch, it is convenient to make A and B electromagnetic switches. We may now merge the three branches, 1, 2-b, and 3, into one circuit which satisfies all of our conditions and requirements.

To extend the procedure to n possible time ordered input conditions, we divide the input conditions into two arbitrary groups. We now have a two input condition problem; that is, either a member of one group will come first or a member of the second group will come first. This will be followed by a series of input conditions belonging to either group. We develop our circuit along the two alternative lines until we have accounted for the maximum terms in the sequence. We now further subdivide our conditions and proceed along the same lines, inserting our subcircuits in our first system. We will eventually reach the point where each group will contain only one member. This is our final circuit. In actual practice, this procedure is too long and involved to be of practical value. Special purpose relays are used in these complex problems. Since such relays are merely variations of the two valued (on and off) relays, one should have little difficulty in developing circuits involving the special relays once he has mastered the use of the two valued relays.

Figure 12. Final sequence diagram.



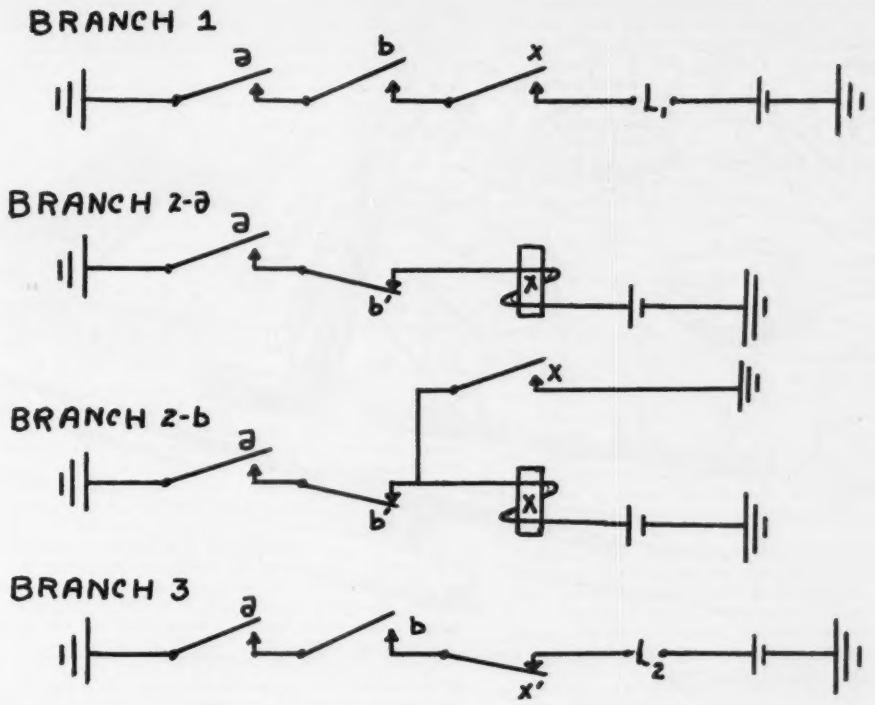
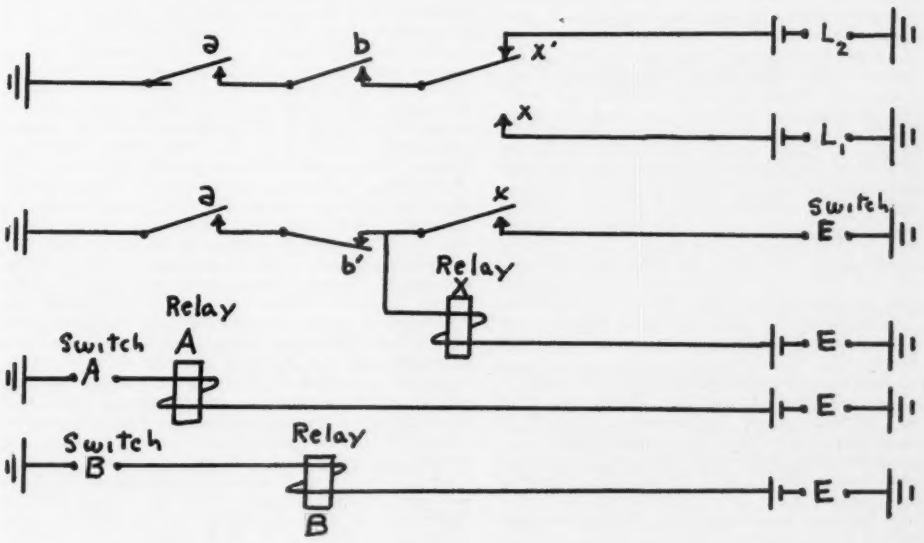
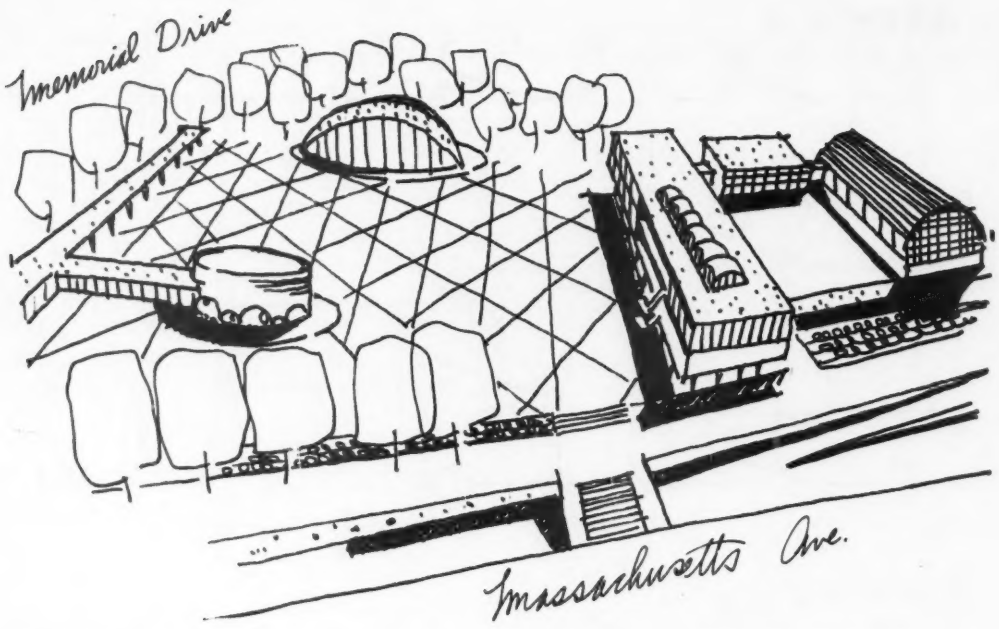


Figure 13. Branches of the sequential circuit.
Figure 14. Final sequential circuit for two ordered switch closures.





A sketch of the Briggs Field of the future, showing, from left to right, the chapel, the auditorium, the Student Union building, and Briggs Field House.

student union

A Plan for the Near Future

By Michael Boylan, '54

Attention at M. I. T. has recently been focussed on the need for a center in which to house such facilities as are needed to fill the expanded social, recreational, and personal requirements of the enlarged student body.

A factor in the consideration of plans for such a Student Union is the increase in enrollment in recent years to a level of around 5,100 in 1952–53, or nearly 65 per cent above 1939–40. In order to house the larger student body, the Institute has in the last few years built or acquired the Baker House, on Memorial Drive — a block west of Massachusetts Avenue, and the Burton House — a former apartment hotel another block further west.

The effect of these additions has been essentially to decentralize the student body by adding the West Campus community to the earlier centers in the East Campus dormitories and the Boston fraternities.

The gradual shift of living facilities and increase in enrollment has so far not been matched by expansion and centralization of the social, recreational, and extra-curricular facilities so necessary for the well-rounded development of the student body. The major segment of the undergraduate activity structure is concentrated in somewhat antiquated quarters in Walker Memorial, which is almost at the eastern extremity of the campus and nearly a mile from the newly-acquired Burton House. Here are the operating quarters of the Institute Committee, the student governing body. The following major activities are there: *The Tech*, the school paper; *Technique*, the yearbook; *Tech Engineering News; Voo Doo*, the humor magazine; the Musical Clubs; the Finance Committee; the Technology Christian Association; the Foreign Student Summer Project; and the Public Relations Committee. Of the more than fifty social, hobby, and honorary activities, only three, Tau Beta Phi, the Debating Society, and the Catholic Club, have office space in Walker. The rest of Tech's extra-curricular clubs and activities are so scattered that any sort of communications or interchange of ideas with Student Government, or anyone else, is virtually impossible. The Hobby Shop is in the basement of the east wing of the main Tech building, the Model Railroad Club is in Building 20, across the campus on the north side, the Student-Faculty Committee has a room in Building 2 on Memorial Drive, and the Athletic Association is in Building 18, in the center of the campus. The Westgate quarters of W1MX, Tech's ham radio station, are roughly two miles from the offices of WMIT,

the undergraduate commercial station, which occupy the basement of Ware dormitory in East Campus.

Obviously, much is to be desired in the direction of activity centralization. The situation will worsen as the Institute carries out its long-range plan of West Campus development. When, at its conclusion, the preponderance of M. I. T. students are housed on the West Campus and to a large extent on the present site of Westgate West at the furthest extremity of the grounds, present activity facilities will have long since become obsolete. It is considered necessary that an activity headquarters be available on the West Campus.

Besides the activities presently housed, there are some ten or fifteen more or less major ones, including the student Judicial Committee, the Lecture Series Committee, and Tech Show, for which no office space exists, or is possible, and whose operations could be benefited by providing some.

Of the few which have offices in Walker Memorial, only the Technology Christian Association occupies space which could be called adequate. *The Tech* is crammed into three badly lit, badly furnished basement rooms with a total of less than eight hundred square feet of area. *Technique* has two tiny rooms, and the Institute Committee, the Foreign Student Summer Project, and the Secretariat one each. The Debating Society, Tau Beta Pi, and the Catholic Club are all in a single ten by fifteen feet pigeonhole.

Recreational facilities are scattered in much the same way, where they exist at all. The only ballroom on Campus is Morss Hall in Walker Memorial, which, from an activity's point of view, suffers from being expensive to hire and very hard to decorate satisfactorily. Such facilities as pool and ping-pong tables, card rooms, and just plain lounging rooms are also few and far between, and often so placed that only the residents of the particular living group where they are located are inclined to use them.

The worst problem, in many ways, is presented by the Techman who commutes or who otherwise for some reason cannot return to the place where he is living for lunch, or during free periods during the day. There is, in fact, no one place where students may go when they are not occupied with classes. Some of the departments have sought to ease this difficulty by providing lounges for students in their courses to use during spare hours, but this is not general practice. Where this appears it has had the effect of still further limiting student communication, since the people one meets in the course lounge are the same as those seen in class every day. The departments, moreover, cannot be expected to provide eating facilities. Therefore, students who cannot return to their dormitory or house must walk a number of blocks to the nearest restaurant or snack bar, which in turn is not close to any place equipped for taking it easy and doing a little homework before the next period.

A Student Union was first visualized in 1942, but after considerable thought and some work on the part of a student committee investigating the plan, the Institute concluded that other needs for available funds were more urgent.

A new development has heightened speculation on the subject and lent a little more weight to the idea of a student center. The legislature of the State of Massachusetts passed, shortly before the national elections, a bill to permit the construction of an underpass for Massachusetts Avenue under the railroad tracks near the Institute. The plan calls for wide access ramps on both sides of the sunken roadway and expanded above- and below-ground parking space. This would require the removal of the Technology Cooperative Store, the Bexley Hall Apartments, and the entire Hennessey block, which houses an electrical equipment company, a restaurant, a bar, a record shop, and a tire and appliance store.

Present Institute plans for the development of the West Campus call for a chapel and an auditorium situated around a plaza north of the Graduate House and across Massachusetts Avenue from the main entrance to M. I. T. Money for these improvements, which patently will make no small contribution to the student center in terms of value to Techmen, is thought to be presently available. It is felt that the student center could be made complete at a single stroke by building on the north side of the plaza one building to accommodate the displaced Cooperative Store and the Student Union.

The real impetus toward reconsideration of the Union was provided by the Baker Memorial Committee, which each year studies worthy campus projects and uses money from the Baker Memorial Fund to implement one in memory of Everett Moore Baker, late Dean of Students. Concurrently Pietro F. Belluschi, Dean of the School of Architecture and City Planning and head of the Institute Administration's Planning Committee, suggested to Hsio Wen Shih, a fifth-year student in Architecture, the designing of a Student Union building as his thesis.

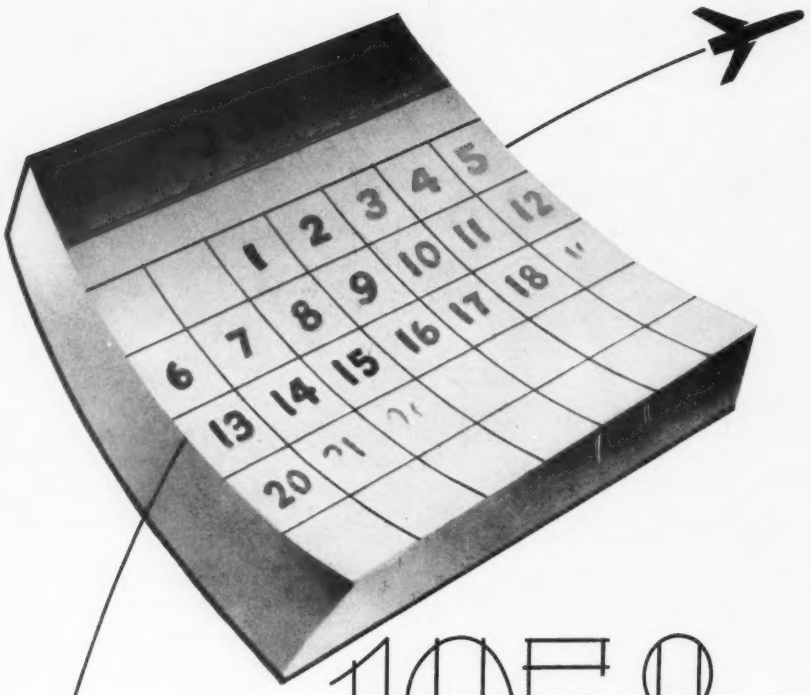
It was early pointed out to the Baker Memorial Committee that the demand for a student center would have to come from the students themselves. Professor T. K. Sherwood of the Department of Chemical Engineering, former Dean of Engineering, outlined the student committee's task clearly on a forum conducted over WMIT as a part of a program aimed at acquainting the campus with the projected Union. Professor Sherwood told a student panel that they should apply themselves to rallying the student body in support of the project, and in the process accumulate enough data on student needs in the field to build a strong case for the Union. He pointed out that it was the M. I. T. Corporation that had to be convinced that the student center was of paramount importance among campus building projects, and that they would be inclined to be critical of any but the most well-thought-out plans.

Accordingly, the student committee charged itself with the task of gathering information on student desires and needs, in this direction, and with publicizing the progress of the project. Out of the information-gathering have come several concrete proposals for facilities to be incorporated into the projected building. Among the most valuable suggestions were those for a branch bank, a ballroom, bowling alleys, rehearsal rooms, lounges, a snack bar-coffee shop which might become a beer night club with a college band, one or two nights a week, a TV room, assorted ping-pong and billiard tables.

Two unusual suggestions proposed a lodge for visiting parents, dates, and people on Institute business and a self-service laundry to supplement the one in Westgate, which is overcrowded.

Wen Shih and Jay F. Koogle '53 early polled all the activities on their space needs, and all feasible requests and suggestions were allowed for in early plans. Enough of the projected floor planning has been done to permit an artist's conception of the exterior of the building.

The committee is presently applying itself to the collection of further ideas. It is hoped that both student body, alumni, and faculty will recognize the significance and practicability of the project and bring its many benefits to M. I. T. as soon as possible and solidification of those at hand.



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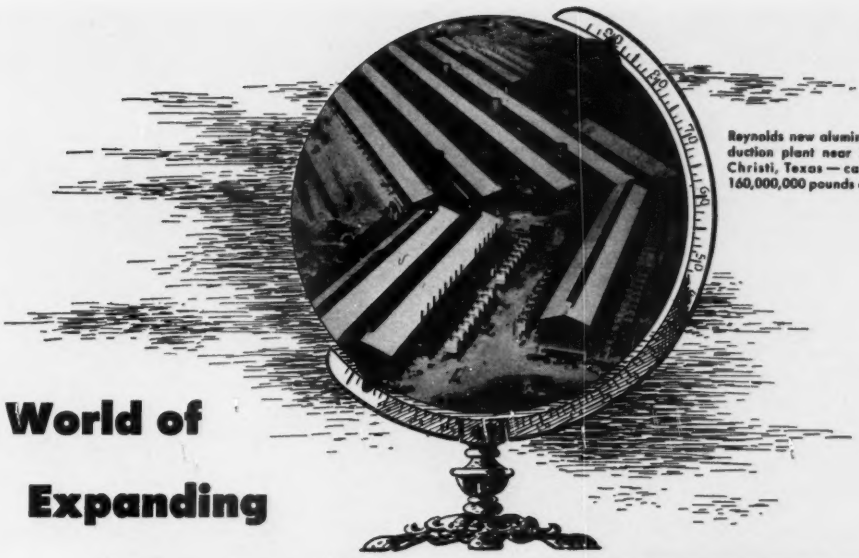

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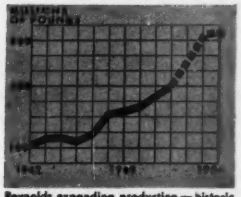

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psycho-electrical dynamics

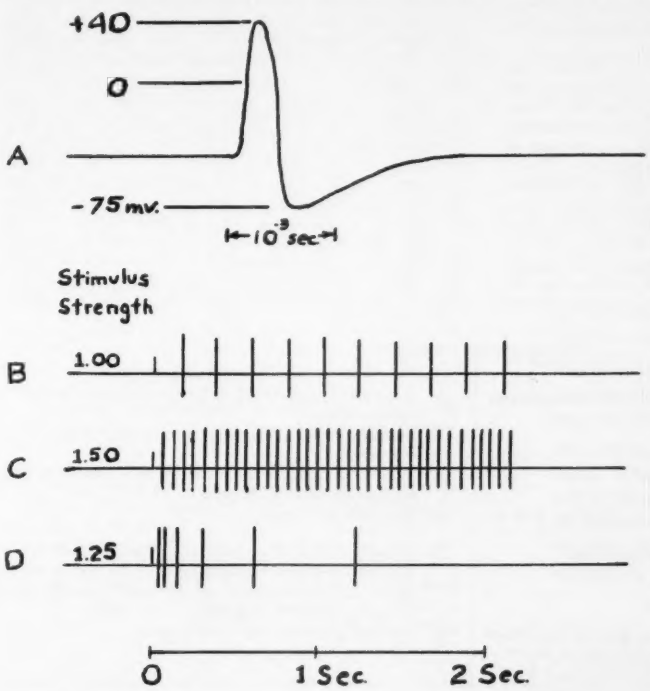
By Arnold Levine, '53

Luigi Galvani, culminating twenty years of work, enunciated in 1791 a theory of animal electricity. He claimed that the motion of the muscles was due to the union of exterior or negative electrical charge with positive electricity which proceeded along the inner muscular nerves. His paper started investigations of the electrochemical behavior of the nervous system which have contributed to a great, though incomplete, knowledge of nervous-muscular phenomena.

Nevertheless, it was not until 1874 that Caton, an Englishman, discovered evidences of electrical activity in the brains of living animals. A series of investigations was begun into the electrical dynamics of the psyche. As a result of these investigations, it was found that there exists a strong analogy between the constitution and operation of the nervous system and those of linear and non-linear circuits; and that psychoses once thought purely functional in nature might be due to "short-circuits" in the neural mechanism. The diagnostic and psycho-therapeutic techniques derived from this viewpoint have proved extremely fruitful; in fact, the inclusion of electrical engineering techniques, assuming neuro-muscular and psychological activity to be electrical in nature, has led to a greater understanding of the effect of the mind on the body, and vice versa.

The advances in electro-neuropsychology in the past few years have been so astoundingly widespread and have touched on so many fields that any brief survey of it must be found wanting. This paper will be limited to a brief discussion of the electrical characteristics of nerves, evidence for the idea that psychoses and bizarre behavior, e.g., epileptic fits or manic-depressive states, arise from faulty "circuits," of feedback methods applied in this field.

A nerve fiber resembles in its operation a relay. A relay is either open or closed, and, depending on its mechanical construction, needs a certain minimum or threshold current to operate it. If the relay responds at all, it responds completely. The same is true for a nerve fiber. A nerve has a "threshold of pain." Below that threshold the nerve will not be activated. Above the threshold a potential impulse can be measured traveling along the nerve, the size of the potential being independent of the intensity of stimulation. After the nerve has responded to a stimulus there is a time interval of about one-thousandth of a second in which it cannot again be activated, no matter how intense the stimulus. After this period, there follows a "relative refractory period" during which the nerve fiber may be activated by only a stronger than normal stimulus. Thus a strong stimulus can produce more impulses per unit time than a weak one. A strong stimulus, therefore, produces a greater frequency of impulses. Evidence has also been found to justify such analogues as diodes, electronic triggering devices, and switching circuits for neural circuits. The decaying polarization potentials of certain motor nerves have been found to resemble the passive charging and discharging of a condenser. The use of equivalent circuits to describe neural circuit behavior may become a possibility when more data is collected. Such a device should prove as useful to the neurologist as it has to the electrical engineer, for



In *A* a typical nerve pulse is shown. The voltage of the center with respect to the outside is shown. *B, C,* and *D* show the response of nerves to stimuli of two second duration and varying amplitude. Note that the height of the individual pulses does not vary to a great extent, but that the repetition rate is affected by the stimulus strength. Some fibers, as in *C,* accommodate to a stimulus and cease responding.

How to lick dust, moisture and acid fog

prevalent in the atmosphere surrounding the Rumford, Me., mill of the Oxford Paper Company posed a problem in power circuit maintenance. The combination of these elements caused wooden structures and even over-voltage insulators to become conducting, resulting in phase-to-phase flashovers and burndowns when ordinary overhead wires were used.

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with it he can use the analogous results already derived by the electrical engineer.

Since the nerve impulse is electrical in nature, the detection of impulses arising from the brain may seem of no more significance than to point up this fact. However, the impulses detected from the brain are unique in that they are rhythmic, i.e., they follow a pattern of amplitude alternating in time sinusoidally. These impulses originate in the cortex, that part of the brain in which the higher psychological processes take place. These "brain waves" are recorded with an instrument known as an electroencephalograph (EEG). The impulses are tapped by electrodes attached to the scalp. A pen, connected to an amplifier and moving up and down linearly with variations in voltage, writes on tape moving perpendicular to the pen's motion. The graphical reproduction is much the same as a series of pictures taken of an oscillating spring and placed side by side. The EEG is taken with the subject's eyes closed, the room being dark and quiet. If a stimulus such as light or noise is introduced, the waves become distorted. If the stimulus is continuous, the waves take on steady state characteristics, i.e., the distortion, or the higher order harmonics, do not disappear, but themselves assume a rhythmic pattern. Should a stimulation "impulse" be introduced, the waves become spiked, of low amplitude and high frequency, with transient effects introduced. In this way, the shape of the waves is the same as the impulse. For example, a sudden light flash will produce high frequency, low amplitude waves, indicating, as in the case of the individual nerves, the correlation between energy of stimulation and frequency of response. One might then say that the phenomenon of brain waves was due to nothing more than impulses in brain nerves, in the sense that they were only physiological in nature and had no correlation to psychological behavior.

It is true that the waves become distorted because of low sugar level in the body, lack of oxygen intake, and physiological effects produced by fright. Nevertheless, it has been found that epileptics, schizophrenic, and manic-depressives show characteristic EEG patterns. In fact, the EEG has become an extremely important instrument in diagnosing latent epilepsy. The latter two cases have always been considered functional. In correlation with these facts, it is known that brain tumors produce disrhythmia (irregular brain waves) and corresponding psychoses; and that persons exhibiting certain social psychoses (those which are caused by a conflict with society) such as anxiety, depression, etc., and persons intoxicated with dope exhibit similar disrhythmia. It would appear, then, that social neuroses and psychoses might arise from the same reason as the psychoses of the victim of brain tumor or dope addition, i.e., the disruption of neural circuits.

Using this viewpoint, the moderate success of shock treatments in treating psychosis might be explained. The procedure has been to either attach electrodes to a person's scalp and produce traumatic electric shock, or to inject a drug, e.g., hexazol, which will produce convulsions. According to psychoanalysts, this mechanism is aimed at producing a state of near death, thereby arousing the survival instincts of the patient, forcing him out of the psychosis which inhibits such instincts. The small number of successes does not warrant such a theory. On the other hand, one might use the analogy

Electro-Neuro Analogies[1]

Engineering	*Neurophysiology*
(1) A sensing or measuring instrument which recognizes an "error," i.e., the deviation from the goal.	(1) A sense organ which may be proprio-, intero-, or exteroceptive.
(2) Amplifying device.	(2) Summation of subliminal impulses to reach threshold level.
(3) Central control to determine goal.	(3) Effective tone in the cells of the central nervous system to determine goal.
(4) Actuators or source of power to achieve goal or correct deviation from it.	(4) Muscles or glands.
(5) Storage elements for storing information.	(5) Memory: from the short and diminishing after discharge in reflexes, to life-long memory on the cortical level. Hypothesis for mechanism includes reverberating circuits, scanning, and others.
(6) Relays and gate: to select the output by inhibition and facilitation, i.e., by logical analysis of input.	(6) Spatial organization of response.

[1] Reprinted in part from Introduction to Some Principles of Applied Cybernetics. Barrett, E. and Post, G., *Journal of Psychology*, 1950, 30, 3–10. See also pages 11–31.

of "shock treatment" used in certain electronic computers to explain the phenomenon. A large current is often sent through the computer when something goes wrong with it, in the hope that such things as a stuck relay or too much bias on a tube might be overcome. There are a small number of successes by this method also.

One can proceed, assuming the brain to be composed of circuits analogous to those known to the electrical engineer, to build an empirical and experimental science aimed at constructing equivalent circuits. A more fruitful method, one that psychologists have lately taken over from the electrical engineer, is the black-box method. One considers only the input and output. The mechanism in between, the black-box, is unknown. To be sure, the psychologist used this method before the electrical engineer. The patient was often viewed as something which was acted upon by his environment. What happened between the input (environment) and the output (his reaction) was unknown. However, one concept, that of feedback, was left out of the repertoire. Feedback is the major ingredient in servomechanism design, and it is in such design that the black-box plays such an important part. Servos often become complex. A detailed investigation of their construction takes a great deal of time. The output in a servo is fed back into the input so that any variation in output affects the input. The effect varies with the reasons for building the servo. In the case of a thermostat, a variation in the temperature (output) is fed back into the input (heat-producing agent), affecting the input in such a way as to compensate for the error in output. For instance, if the temperature were too high, it would be fed back to the input so that less fuel would be put on the fire, thus lowering the temperature. In the case of anti-aircraft tracking servos, the output (pointing position of the gun) is fed back to the input (position and velocity of plane), so that a correlation between the two can be computed. Feedback plays an important part in the human motor system. An example of this is given by Norbert Wiener.[1] He explains that in reaching for an object, the eye judges the distance to the object, relaying this information to the brain, which then moves the arm closer to the object. The information "how close" is given by the eye back to the brain, which again moves the arm closer. In some forms of ataxia and flaccidity, this mechanism is at fault, leading to under- or overshooting of the goal, or just a forestalling of activity. For analogies between the characteristics of servos and the corresponding characteristics in human beings, see the table below. The black-box method has been extremely successful in engineering applications. How successful it will be in psychology is yet to be demonstrated. Nevertheless it has already given insight into the dynamics of the human nervous system.

The above has presented a very brief, and inadequate, survey of a new field, electro-neuropsychology, some of its results and ideas. It is apparent that the coming neurologist will have to have a strong grounding in the engineering sciences, and will himself be able to contribute to these sciences. With the inception of the field idea of electricity by Faraday, this strange new idea was explained by use of analogies to the well-understood fluid flow. Today, the reverse is true. The world lives more closely with electricity, and fluid mechanics often uses electrical terms as its analogy. Perhaps some day the roles of electro-neuropsychology and electrical engineering may be reversed, the neurologist supplying the analogies to the EE for the understanding he needs for better machines.

[1] "Cybernetics." Wiley (1948), 14–15.

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arithmetic in digital computers

By David Sternlight, '54

In the January 1953 issue of *T. E. N.* there appeared the first in a series of articles on digital computers dealing with the problem of computer "memory." The purpose of this article is to talk about arithmetic in computers, and at some future date we will discuss control systems, and perhaps deal with analogue computers.

A	B	S'	C'
0	0	0	0
1	0	1	0
0	1	1	0
1	1	0	1

Table 1. The behavior of a 1/2a.

The basic arithmetic element in a digital computer is the half-adder. This ½*a* is illustrated in figure 1. It has two inputs and two outputs, and from table 1 below, we see its action with varying inputs. By the proper connection of two ½*a*'s, we obtain a binary adder, which adds numbers in the binary system. This "binary adder" is illustrated in figure 2.

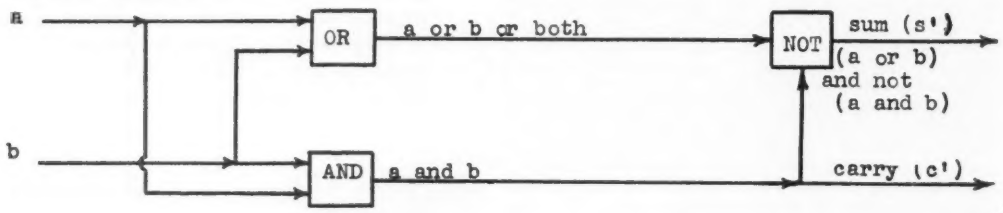
A word about binary numbers is in order here. Since electronic tubes, relays, etc., have only two distinct conditions, off and on, the numbers dealt with in digital computers have to be in binary form. These numbers are merely written to the base two, instead of to the base ten, as decimal numbers are. Just as 234.7 is 2×10^2 plus 3×10^1 plus 4×10^0 plus 7×10^{-1} in the decimal system, 1011.1 is 1×2^3 plus 0×2^2 plus 1×2^1 plus 1×2^0 plus 1×2^{-1}. 1011.1 binary, by the way, is equal to 11.5 decimal. There are several very cute ways of converting from one number system to another by successive multiplications or divisions, utilizing the remainders. Further information on this topic can be found in any good text on theory of numbers.

A further word is necessary here on "and," "or," and "not" circuits as used, for example, in the ½*a*. An "or" circuit puts out a pulse if either of the inputs or both are ones. An "and" circuit puts out a pulse only if both its inputs are ones, a "not" circuit puts out a pulse if either of the inputs are ones, but not both.

Armed with this information, we can now see how a ½*a* (half-adder) and a binary adder work. These adders operate serially only; that is, they add one column of figures, put out a result, and then they proceed to the next column. Needless to say, a great deal of time is lost by having to sit around and wait, as it were, for one column to clear before the next can be fed in. To remedy this situation, the parallel adder was developed. This type of adder, although a little more complicated, can add as many columns as desired simultaneously, handling the carry digits at once also. The only limitation is in the initial construction, that is, if we wish to be able to add up to fifteen columns of figures, we must build fifteen column-units into the adder initially.

The parallel adder makes use of three basic components. The first is the flip-flop. This is simply a unit which changes its conducting state (from conducting to non-conducting, or vice versa) each time a pulse enters the input. When it goes from one to zero, it puts out a "carry" pulse on the output lead. This output lead can then be connected to a second flip-flop, representing the next column of figures, and so on.

Figure 1. Half-adder.



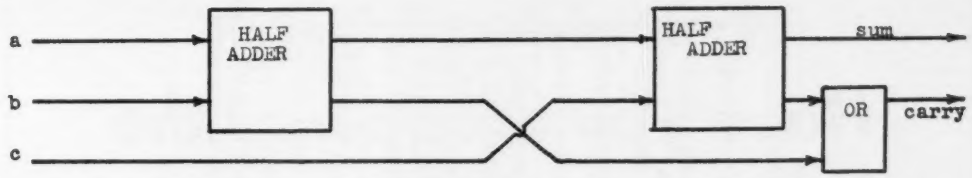


Figure 2. Binary adder.

The second component used in the parallel adder is the gate circuit. This circuit will allow a pulse to pass through it only if there is another pulse present at the "bottom" lead of the gate. It is very useful, for example, in permitting a pulse to enter the carry circuit only when there is a one in the flip-flop.

The third component of parallel adders is the delay circuit, which is used to prevent two pulses from arriving simultaneously at the same point.

We symbolize the flip-flop by *FF*, the gate by *GT*, and the delay by *DE*. With this in mind, figure 3 shows a parallel adder with high-speed carry. After the numbers to be added in columns A, B, and C have been fed in, and the partial sums formed by the flip-flops, the carry bus is pulsed once, and the carry operation is performed. Note the outputs at *X* and the inputs at *X'* so that this adder may be cascaded with others. To make this simpler to understand, figure 4 shows a parallel adder, with the carry digits stored, so that this circuit merely adds the digits in columns A, B, and C, and stores the carry digits in *FF1*, *FF2*, and *FF3*, associated with these columns.

You may have noted that the upper *FF*'s in the high-speed carry circuit have two inputs, one on either side, rather than one in the center. Rather than reverse the state, the purpose of these inputs is to insert digits bodily, a "one" being inserted if a pulse appears on the right-hand input, and a "zero" if the pulse comes down the left-hand input to these flip-flops (*FF12, 13, 14* in the illustration).

By now you may have realized that the digital computer does not add; it counts. But is not all addition basically counting? Remember when you were a child; you used to count on your fingers. The "fingers" of a digital computer are its flip-flops.

The *FF*'s, *GT*'s, and *DE*'s are very versatile circuits, and can be used in many digital computer applications.

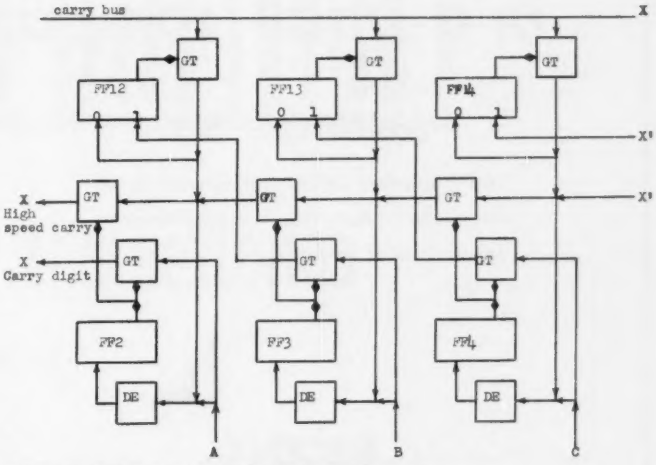


Figure 3. Parallel adder with high-speed carry.

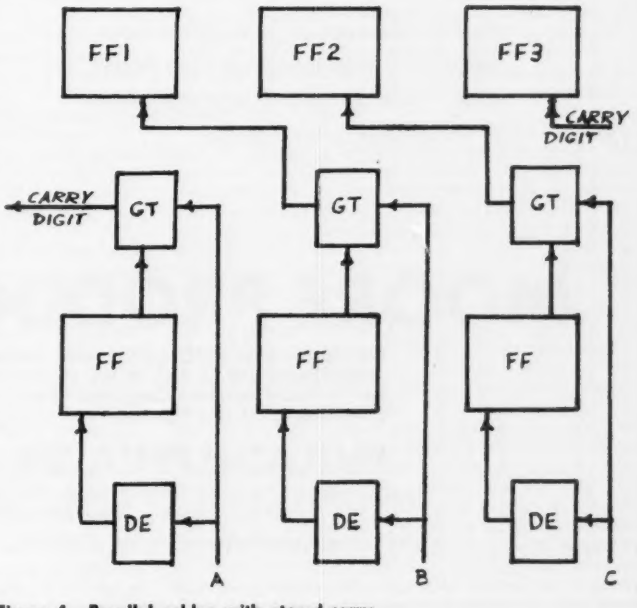


Figure 4. Parallel adder with stored carry.

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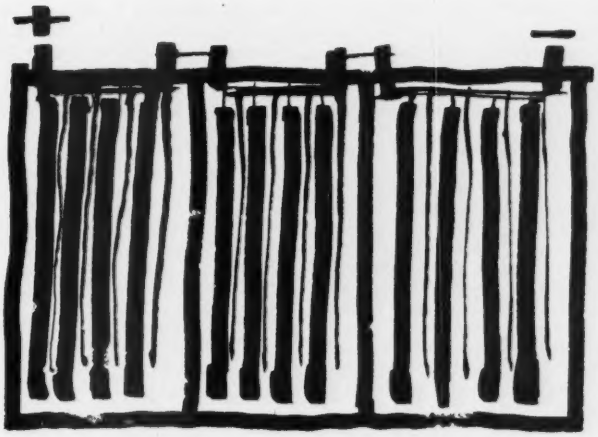
battle of batteries

improvement to be brought about by AD-X2, Dr.



the battle of the batteries

By John Wells, '54

An unprecedented situation now confronts the Senate Small Business Committee and the National Better Business Bureau, for they must decide who is "right" — the National Bureau of Standards or the Massachusetts Institute of Technology.

The technical controversy concerns a battery additive designed to prolong the life expectancy of lead acid storage batteries. This product, known as Battery AD-X2, is produced by Pioneers, Inc., of Oakland, California, and is described as containing sodium and magnesium sulfates plus "certain trace elements."

The product, according to the manufacturer, enjoyed a certain measure of success until the National Bureau of Standards in 1948 tested and found the product worthless, as it had found all battery additives of this type over the years.

Early last year, Jess M. Richie, president of Pioneers and developer of AD-X2, naturally convinced of the value of his product, asked the assistance of the Senate Small Business Committee in proving its value. The committee requested M. I. T. to conduct and analyze a series of tests on the product as a public service and at no cost to the government. Participating in the M. I. T. tests were Professors Harold C. Weber, James A. Beattie, and George P. Wadsworth. Dr. J. G. Bryan assisted Professor Wadsworth in the statistical analysis. The M. I. T. technical report clearly indicated that the additive, AD-X2, not only met the claims of the manufacturer, but possessed many additional advantages. These results were in direct conflict with the results of the NBS investigations.

At this point, a brief discussion of what causes the limited life of a lead storage battery may be of value in evaluating the significance of the results of the large number of tests performed with this additive.

One important reason for the short life of a battery is the formation of hard lead sulfate on discharging which is difficult to bring back into solution on subsequent charging. This phenomenon is well realized by car owners who have allowed their batteries to stand in a discharged condition for any length of time. Dr. Keith J. Laidler, an associate professor of chemistry at the Catholic University of America, who wrote a discussion of the NBS and M. I. T. reports, discusses this phenomenon in detail:

"The effects of this hardening are quite far-reaching and the following in particular may be noted. The hardened lead sulfate crystals tend to grow, and may eventually fracture the positive grid frames or warp the plates, and later may split the separators or fracture the cell partition. As the growing lead sulfate crystals close the pores in the active material it becomes increasingly difficult for the electrolyte to penetrate into the plates, and the capacity of the battery is thus reduced; if the capacity of the battery is reduced and the charging current remains the same, the water loss due to electrolysis becomes greater. The resistance increases due to the minute solubility of the lead sulfate crystals, bring about an increase in temperature on charging and this in turn causes a more rapid evaporation of the battery fluid. Flaking is also caused by hard sulfation, due to enlarging of the crystal; as the sulfate in the negative plate becomes hard it may shrink away from the grid, thus making poor contact and allowing large bubbles of gas liberated in charging to pass between the grid and the active material, encouraging further shedding. Shed material collects at the bottom of the battery container, and when sufficient shedding has occurred that the battery mud touches the bottom of the plates the cell is shorted and becomes dead. Hard sulfated

active material in the positive plate, being inert, causes the charging current to be passed at the grid, which itself is converted into lead peroxide. Since peroxide is a very poor conductor and has very little strength, there is a reduction of the ability of the grid to pass the current to and from the plate, and its lack of strength allows the plate to fall apart."

Thus, it is obvious that any additive that would prevent the hardening of the sulfate or cause hard sulfate to go into solution more rapidly on charging would be a great improvement to batteries. A number of salts have been tried over the years, among them sodium and magnesium sulfates, which were found to be effective in rendering the hard sulfate easier to get into solution. However, the use of these salts also imposes a notable disadvantage; they cause the electrode materials to shed and to fall to the bottom of the battery. Therefore, the relief is temporary; the battery may charge readily but will not last very long.

After many years of testing battery additives, all attempting to have the desirable properties of increasing the rate of solution of hard lead sulfate and not the accompanying detrimental effect of causing the plates to flake, the NBS found them all to be ineffective if not harmful to batteries, including AD-X2.

The compound AD-X2 supposedly had the desired effect of combating hard sulfation. When manufactured and marketed, it had enjoyed considerable commercial success until the setback caused by the NBS report which concluded that all battery additives were worthless. This report was subsequently circulated by the Better Business Bureau as a service to the business community. It is not surprising, in view of the reputation of the NBS, that Pioneers, Inc., was seriously handicapped by the report.

In his discussion of the conflicting reports on AD-X2, Dr. Laidler divided the tests into two main classes:

"1. Tests in which discarded batteries, which would not take a charge, were treated and then placed on charge.

2. Controlled tests carried out with a number of similar batteries, some cells being treated and the others not; comparisons are then made between the two sets of cells."

On the tests that had been carried out on AD-X2, Dr. Laidler states that in drawing conclusions on the basis of the numerous tests it is important to realize that negative results are not necessarily a reflection on the product; they may be a reflection on the methods of carrying out the test. "There are many factors that will lead to the impression that the material has no good effects. . . ."

In commenting on these tests, Dr. Laidler states: "In all cases these tests showed positive results. Uncontrolled tests of this kind, however, can be criticized on the grounds that one cannot ever be certain that a battery will not take a charge; it is possible that on additional charging a battery would have taken the charge even if the additive had not been used." The experience of the battery men with regard to the expected lifetimes of their batteries and the successful results at various large installations is particularly convincing, to Dr. Laidler, that these tests have some value.

Tests on AD-X2 have also been conducted at the laboratories of the U. S. Air Force, the U. S. Signal Corps, Chief of Ordnance, and Navy Department (Bureau of Ships). Although in all of the reports the statement is flatly made that the results indicate no improvement to be brought about by AD-X2, Dr. Laidler states, "In no case, however, is an adequate statement made as to exactly what was done, . . . consequently, it is quite impossible to know whether the results are really negative, or whether they have been so interpreted as a result of personal bias. It is extraordinary that service organizations should have prepared reports on this important problem in so utterly incompetent a manner." Dr. Laidler maintains that, although the same test specifications were furnished by the manufacturer for the Air Force, Chief of Ordnance, Signal Corps, and the Navy tests, the carrying out and reporting of the test was only done satisfactorily by the Air Force, which concluded the product to be valuable.

Regarding the NBS tests, Dr. Laidler observes, "In the tests described in National Bureau of Standards Circular 504 only one battery was used for each additive. Two cells were treated and one was untreated; the inadequacy of the control used here does not require comment. . . . The test carried out in June 1952 was much more comprehensive and superficially is much more satisfactory. The results were submitted to an elaborate statistical analysis, and the Bureau concluded the material to be worthless. . . ."

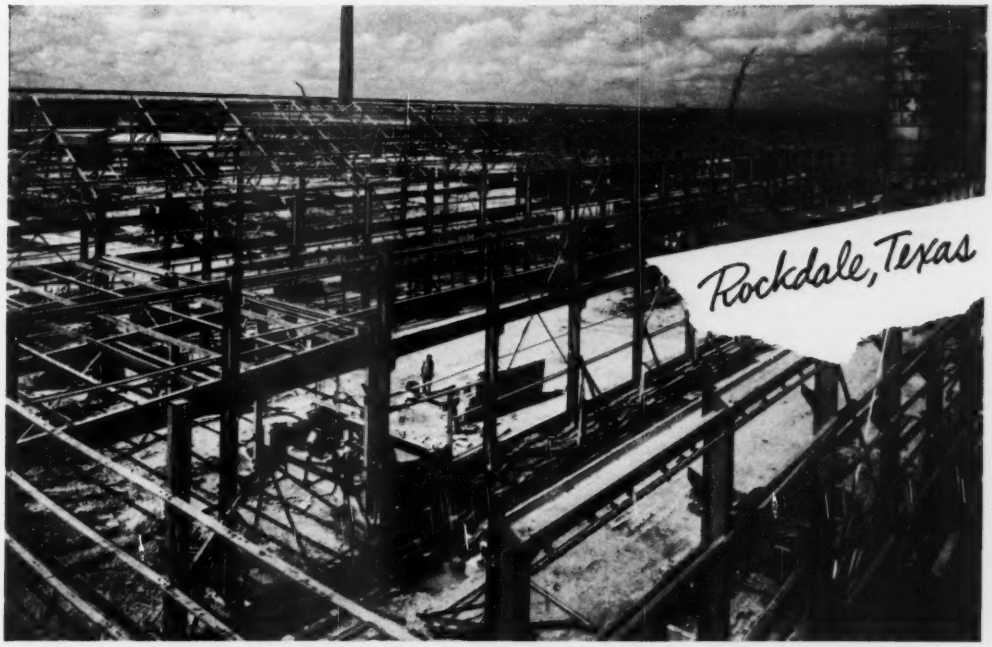
A number of serious objections were raised by Dr. Laidler as to the procedure in which the recent NBS tests were conducted. The batteries, he says, were evidently not in poor condition due to sulfation since all of them, untreated as well as treated, came up to practically full capacity on charging. Improper statistical analysis, failure to adhere to the manufacturer's instructions in making the test, failure to report certain important results, and the failure to report actual times and voltage readings were also among Dr. Laidler's objections of the NBS tests. It is interesting to note that the NBS asserts that the manufacturer selected the batteries to be used in the tests, supervised their mechanical renovation prior to testing, and participated in part of the tests.

On interpreting the NBS results, Dr. Laidler found that they indicate, contrary to the Bureau's claims, the material to be indeed effective. He claims that they show this with respect to significantly lower temperatures and the higher specific gravities of the treated cells, which leaves "no question but that the National Bureau of Standards tests do in fact reveal a more rapid charging of the treated cells. . . . The Bureau staff has apparently completely ignored this factor, since their statistical procedures could not reveal differences in charging velocity. On the contrary, by lumping all of the data together they have smeared out all differences between treated and untreated cells.

"Our conclusion is therefore that the National Bureau of Standards results do show significant differences in favor of Battery AD-X2. These differences would undoubtedly have been accentuated had the actual work been done more carefully."

The tests carried out by M. I. T. are described in a lengthy report. These tests, according to Dr. Laidler, constitute by far the most thorough scientific tests of the effectiveness of Battery AD-X2. He states:

"Perhaps the most striking results of the test are those obtained from experiments in which cells were subjected to a short charge, after which discharge times were measured. In many cases discharges were carried out three or four times, sometimes with additional charging and sometimes with merely a resting period. Treated and untreated cells were given identical treatment as far as charging and discharging were concerned, and the results show that the discharge times were significantly longer for the treated cells. This seems, of course, that the treated cells acquired a higher capacity on charging.



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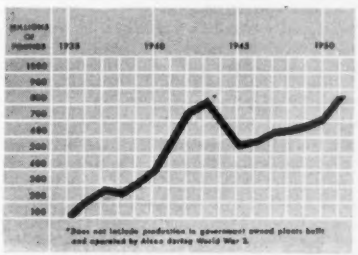

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battle of batteries

Since the charges were short ones and conclusion is that the treated cells accept a charge more rapidly than the untreated ones.

"The statistical analysis of these results is particularly convincing. The statisticians analyzed the results in a number of different ways, all of which shows the improvement due to AD-X2 to be significant, some to be highly significant."

A summary of the M. I. T. results is as follows:

(a) Among the cells in any chosen battery, all cells in such battery, having been subjected to the same previous history, except for treatment with AD-X2, treated cells showed larger capacities than did untreated cells, both being subjected to the same conditions of discharge.

(b) When AD-X2 was added to cells containing sediment, the amount of sediment decreased both while the battery was on charge and when it was not on charge.

(c) Cells treated with AD-X2 when on charge presented a markedly different appearance from those on charge without treatment. The gas evolved in the treated cells was in the form of minute bubbles, while that evolved in the untreated cells was in bubbles estimated to be four to ten times as large as those evolved in the treated. The liquid surface in the treated cells presented a different appearance from that in the untreated cells.

(d) The surface of a negative plate in a treated cell was distinctly softer than the surface of a similar plate in an untreated cell, both having been subjected to the same charge conditions. Often, softening was first evident near the edges of the negative plate.

(e) Under similar charge conditions, treated cells lost less liquid than untreated cells.

(f) Under identical conditions of charge, treated cells operated two to five degrees Fahrenheit cooler than did untreated cells, the differences being greater than could be explained on the basis of the treating material added.

(g) During charge, and starting with discharged cells, treated cells gave higher hydrometric readings than did untreated cells, the differences being greater than could be explained on the basis of the treating material added.

In addition, Dr. Laidler concludes that the additive has been "clearly and repeatedly demonstrated to be effective in diminishing the harmful effects of sulfation in lead storage batteries," and that the manufacturers' claims are more than justified.

An interesting psychological discussion of the situation was also presented by Dr. Laidler in which he presumes to explain "how the Bureau could dare to make such grave errors." It seemed to Dr. Laidler that a strong bias existed in the NBS, having worked with batteries for many years, that the possibility of any improvement in batteries was inconceivable: "How preposterous that Ritchie, not even a scientist let alone a Ph.D., could develop anything that the pundits had not thought of before! . . . Consequently they were simply psychologically incapable of giving Battery AD-X2 a fair trial." In closing, Dr. Laidler states that a "substantial saving in battery costs could be achieved by the universal use of Battery AD-X2 in batteries and a large part of this saving would accrue to the United States Government, which is a very extensive user of batteries."

Although the M. I. T. report may appear overwhelmingly conclusive to Dr. Laidler, a number of conflicting views on the significance of the results obtained

were offered by several authorities in the field. Allen V. Astin, director, National Bureau of Standards, says that:

"The Bureau has confidence in its findings in this field, and is aware of no scientific basis for questioning its conclusions with respect to any battery additives. The Bureau would like to stress, however, that there would be no hesitation on its part to amend its position were satisfactory scientific data available establishing any value for such materials.

"The National Bureau of Standards has not yet received a copy of the M. I. T. report, but portions and interpretations of it have appeared in the Senate Committee's release. Such information presently at hand regarding the M. I. T. report does not contradict the findings of the National Bureau of Standards for the relationship of the M. I. T. study to normal battery operation is not obvious. It is interesting to note that the M. I. T. report, in at least one place, carefully avoids a claim that they have established properties which are beneficial to *normal battery operation*" (italics my own).

A number of men in the battery field continue to doubt the value of the findings of the M. I. T. tests in view of their experience with similar materials, the professors' lack of "practical experience" with batteries, and the feeling of being overwhelmed by "a mass of irrelevant or nonpertinent data presented by those who can out-talk him," as W. C. Rose, assistant chief engineer, Willard Storage Battery Co., commented: "Who is to decide whether results are significant or not in battery service? Surely not college professors without any practical experience in the battery industry even though they review these theoretical phases of battery chemistry correctly."

Mr. Kenneth Wilson, Director of the National Better Business Bureau, did not know whom to believe when last seen by the author.

It is interesting to note that the M. I. T. results were submitted without interpretation, and the men involved in the tests offered no further comment on the report to this author when interviewed, thus leaving the interpretation of the carefully compiled data to others and thereby avoiding any possibility of embarrassment.

The primary interest of this situation to us may not lie in whether this battery additive is effective or not, although this may be of great importance, nor in the fact that a routine test led to a four year battle, but in the peculiar circumstances by which it arose. It emphasizes, again, that the human element is a very difficult thing to eliminate in science as in anything else, not only when the time finally comes to interpret the mass of accumulated data but also in the means and methods by which those data resulted.

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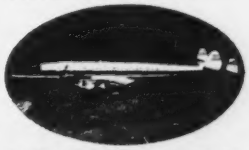

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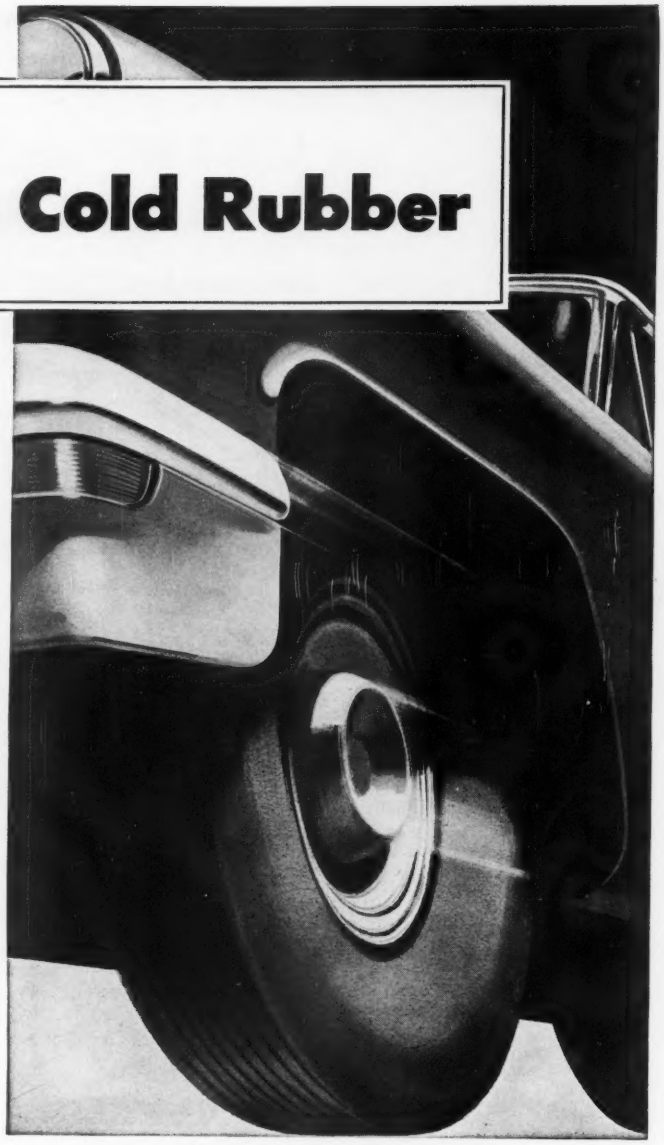

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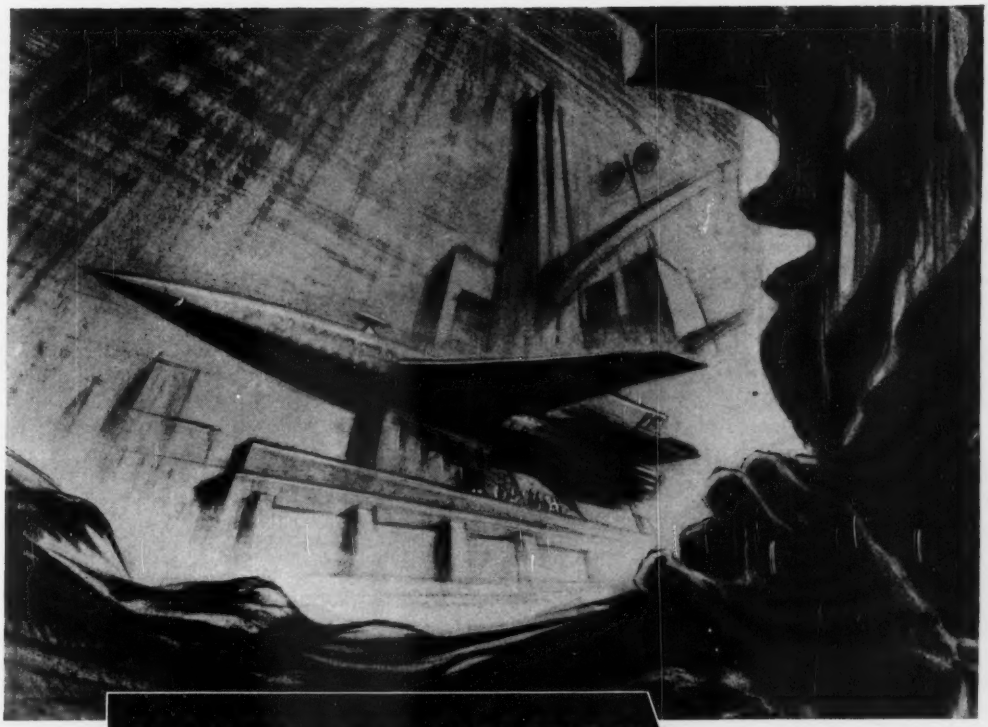

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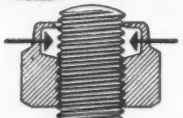

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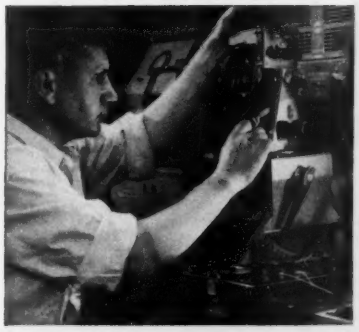

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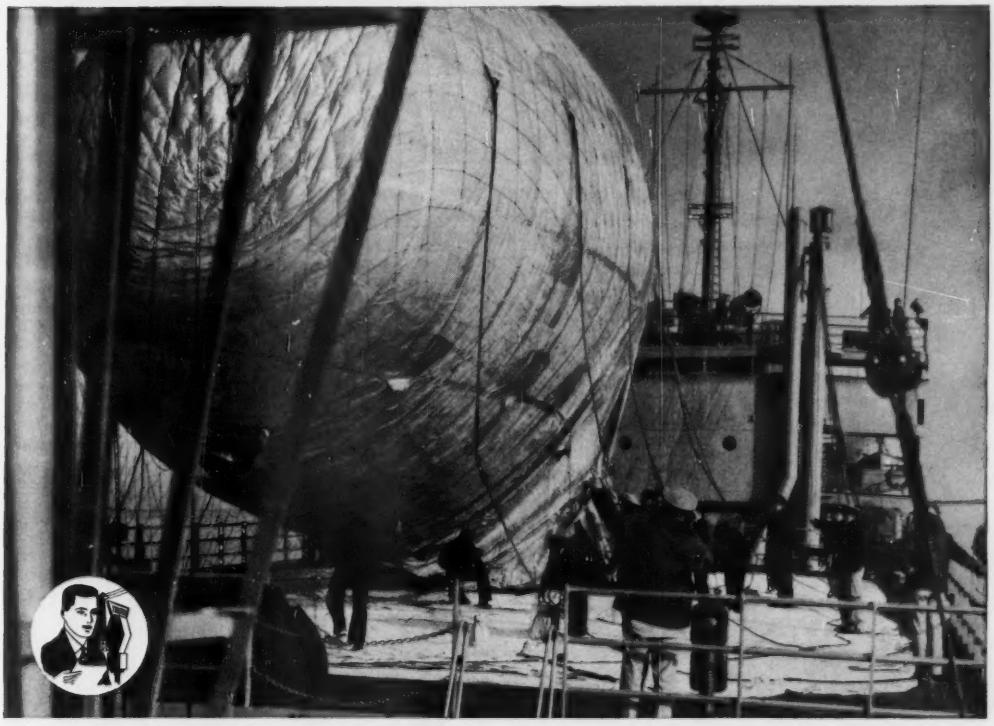

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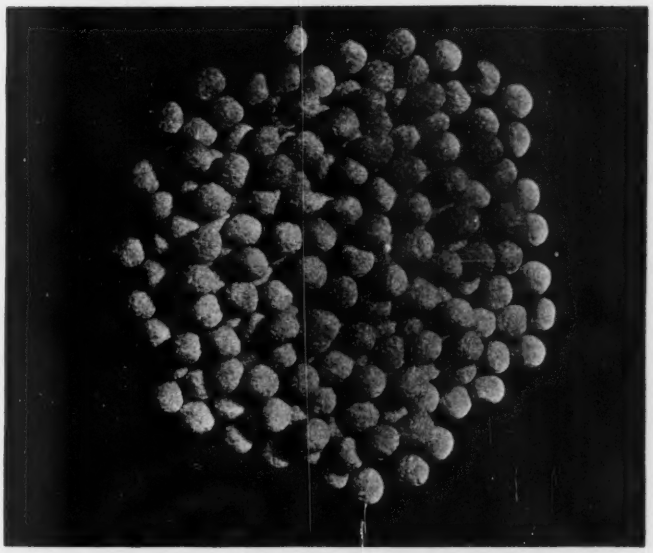

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Water absorption values of these supports vary from 12% to 22% by weight. Surface areas by the nitrogen absorption method range up to about one square meter per gram. Crushing strengths vary from 20 to 600 pounds, depending on size and shape, and bulk densities range from 60 to 80 pounds per cubic foot.

Many Refractory Products

Catalyst supports are but one of many refractory products made by Norton. These include small furnace refractories such as tubes, cores and muffles; large furnace refractories such as bricks, plates, muffles and other shapes; refractory cements; refractory laboratory ware; kiln furniture for ceramic plants.

In its search for refractory products that can be used at higher and higher temperatures, Norton has developed a line of pure oxide refractories. These refractory shapes, as their name implies, are molded without bond and then fired at sufficiently high temperatures to produce a truly sintered product.

The principal raw materials used in the manufacture of Norton pure oxide refractories are ALUNDUM (fused alumina), MAGNORITE* (fused magnesia), fused stabilized ZIRCONIA and, to a limited degree, fused thoria.

Planning Your Future?

Norton Research is continually developing better products to make other products better. Young technicians who are interested in contributing to the technical advances of the future will find Norton Research well worth investigating.

Free Booklet on

longer lasting Norton refractory products contains detailed descriptions of Norton contributions in this field. Write for your copy.

Norma L. Gullberg, A.B., Chemistry, Clark University '46, takes a reading with an optical pyrometer on a high temperature furnace used for catalyst support tests.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

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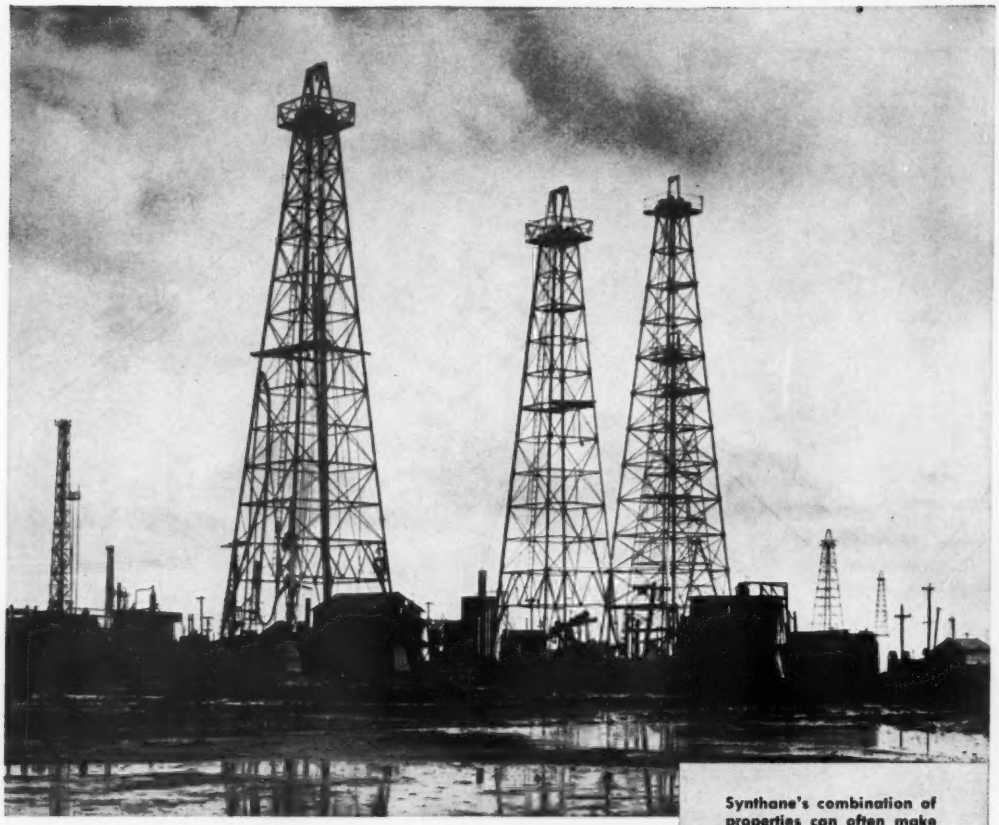


From crude to crankcase— with an assist by SYNTHANE

Without oil there'd be no automobiles or airplanes, fewer plastics, soaps, drugs, floor polishes, cosmetics, insecticides.

In one form or another, petroleum and petrochemicals are almost as important to us as the air we breathe. And in one way or another, Synthane plastic laminates are equally important to petroleum production and processing.

The reason is understandable. Synthane is a dependable material with many uses.

Because it is wear-resistant and tough, yet easy to machine, Synthane is used for components of oil well cementing equipment. Because Synthane is strong and corrosion-resistant, it is excellent for pump valves, piston rings, and compressor plates in tank-farms and refineries. Because it is a good insulator, Synthane in the form of flange insulation provides cathodic protection for pipe lines. Because it is a good moisture-resisting dielectric, light weight Synthane is used in geophysical survey equipment and oil-locating instruments. Wear-and-corrosion resistance make Synthane desirable for flow-line valve-seat inserts.

Because of all these valuable properties, plus many more, Synthane may be a material you can put to profitable use. To find out, get the complete Synthane Catalog. Write to Synthane Corporation, 42 River Road, Oaks, Pennsylvania.

Synthane's combination of properties can often make a good product better.

Strong, light, durable. High tensile, compressive and flexural strengths.

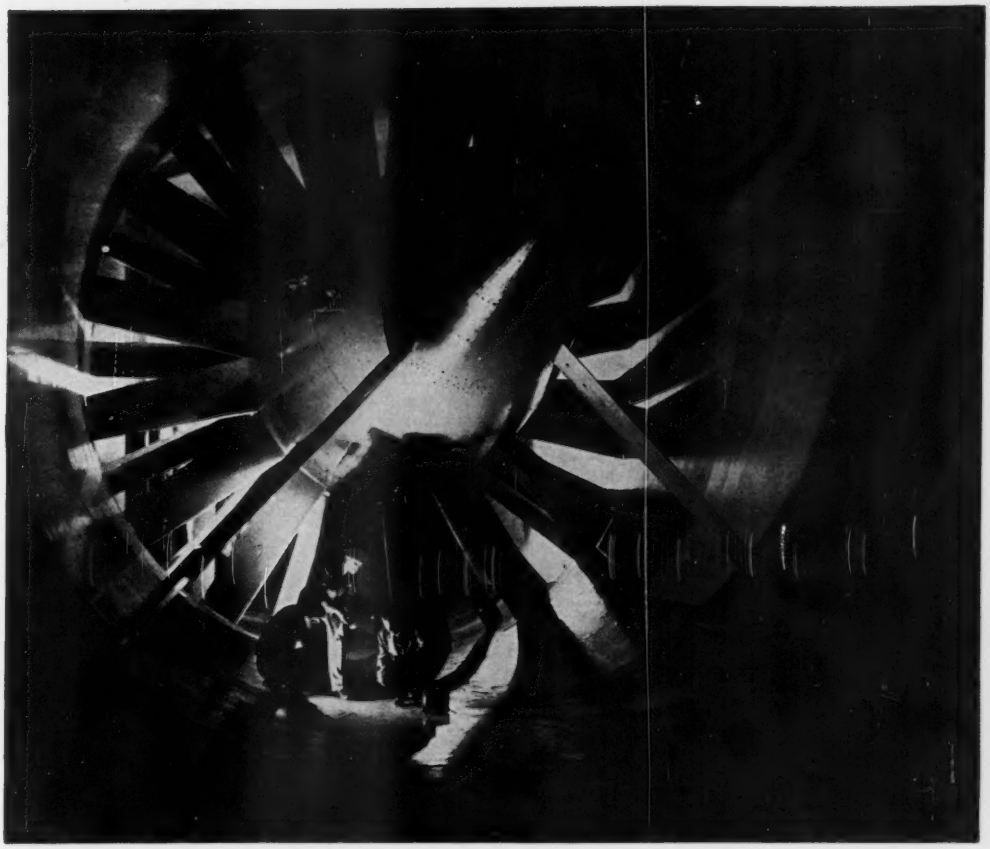
Good insulator; high dielectric strength, low power factor. Low dielectric constant.

Resists moisture, oil, solvents, and corrosive atmospheres.

Synthane—one of industry's unseen essentials

SYNTHANE

LAMINATED PLASTICS



Boeing's great new tunnel can help you

Whatever engineering field you enter, you'll get ahead faster if the company you join possesses outstanding research facilities. Boeing's newly redesigned 54,000-hp. wind tunnel – the only privately owned trans-sonic tunnel in the country – is an example of the research advantages that could help you get ahead in this famous company. Other research tools at Boeing include acoustical, hydraulic, pneumatic, mechanical, electronics, vibration and physical research laboratories, among others.

No industry matches aviation in offering young engineers such a wide range of experience, or such breadth of application – from pure research to production design, all going on at once. Boeing is constantly alert to new techniques and materials, and approaches them without limitations. Extensive sub-contracting and major procurement programs – directed and controlled by engineers–afford varied experience and broad contacts with a cross-section of American industry.

Aircraft development is such an integral part of our national life that young graduates can enter it with full expectation of a rewarding, long-term career. Boeing, for instance, is now in its 36th year of operation, and today employs more engineers than at the peak of World War II.

Boeing engineering activity is concentrated at Seattle in the Pacific Northwest, and Wichita in the Midwest. These communities offer fine fishing, hunting, golf, boating and other recreational facilities. Both are fresh modern cities with fine residential and shopping districts, and schools of higher learning where you can study for advanced degrees.

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BOEING

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"In the course of almost every fire," said George Eastman, founder of Eastman Kodak, "there is a time when a teacup or a pailful of water will put it out. There is another time, later on, when it takes all the water that can be pumped. There is a well-tried scheme for providing the water to put the fire out when little is required . . . the automatic sprinkler system!"

Positive fire protection — whether buildings are "fire-proof" or not — means stopping fire at its start. A Grinnell Automatic Sprinkler System offers such protection — stops fire at its source, wherever and whenever it strikes, night or day, *automatically*. Seventy-four years experience proves this.

People who rely on fire insurance alone are forgetting something. No indemnity check can ever fully compensate for the loss of property, materials, records or profits . . . or the loss of a single life. How much better to prevent needless loss of life and property in plants, warehouses, stores, theaters, clubs, hotels, schools and hospitals — with Grinnell Automatic Sprinkler Systems.

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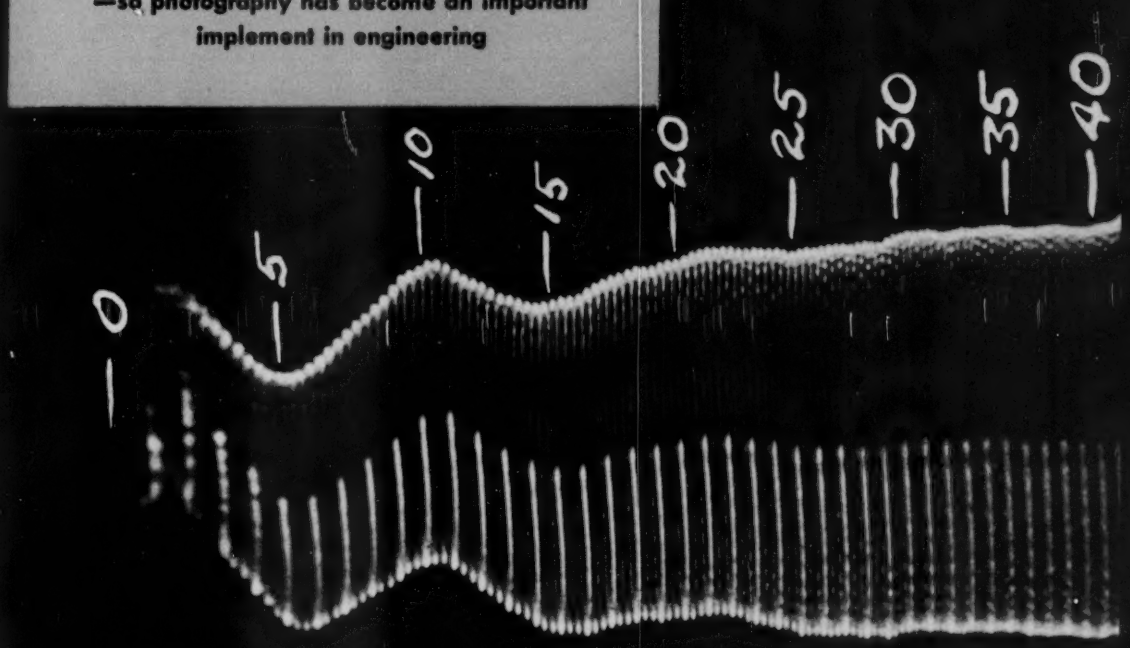

This picture is a photographic recording of a cathode ray oscilloscope trace which shows the speed of the reaction of lithium borohydride with an aqueous acid solution.

PHOTO COURTESY OF THE DEPARTMENT OF CHEMISTRY, ILLINOIS INSTITUTE OF TECHNOLOGY, CHICAGO, ILL.

● In the laboratory, in the design department, the production shop and assembly line, in fact all through modern engineering operations, photography is revealing new information, recording facts, aiding new developments, saving time and conserving effort.

Photography can capture the fleeting flick of the cathode ray, trace, and record important engineering information. It can reproduce engineering drawings—microfilm valuable data for easy transportation or space-saving storage. And high speed movies can slow down fast motion so that it can be seen and studied.

In fact, there are so many ways in which photography aids engineering and so many new applications being found, that many well-qualified graduates in the physical sciences and in engineering have been led to find positions with the Eastman Kodak Company.

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MY QUESTION TO THE G-E STUDENT INFORMATION PANEL:

"How does your business training program prepare a college graduate for a career in General Electric?"

...CHARLES O. BILLINGS, Carnegie Institute of Technology, 1954

The answer to this question, given at a student information meeting held in July, 1952, between G-E personnel and representative college students, is printed below. If you have a question you would like answered, or seek further information about General Electric, mail your request to College Editor, Dept. 123-2, General Electric Company, Schenectady, New York.

R. J. CANNING, *Business Training Course* . . . General Electric's business training program offers the college graduate the opportunity to build a career in the field of accounting, finance, and business management in one of the most diversified companies in the country.

Since its beginning in 1919, more than 3,000 students have entered the program—one of the first training programs in business to be offered by industry.

The program's principal objective is to develop men well qualified in accounting and related business studies, men who can become administrative leaders in the financial and general business activities of the Company.

Selection of men for the program is based on interviews, reviews of students' records, and discussions with placement directors and faculty members. Selection is not limited solely to accounting and business administration majors. A large number of men in the program are liberal arts graduates, engineers, and men with other technical training.

When a man enters the program he is assigned a full-time office position in accounting or other financial work and enrolled in the formal evening education program. This planned classroom work is a most important phase of the program. The material presented is carefully selected and well integrated for the development of an adequate knowledge of accounting and business theory, procedures and policies followed by the Company, acceptable accounting and business practices of the modern economic enterprise, and as a supplement to the practical experience provided by the job assignment.

In general, the program trainee is considered in training for three years during which time advancements are made to more responsible types of accounting work. After completing academic training the trainee's progress and interests are re-examined. If he has demonstrated an aptitude for financial work he is considered for transfer to the staff of traveling auditors or to an accounting and financial supervisory position. From here his advancement opportunities lie in financial administrative positions throughout the Company. Trainees showing an interest and aptitude for work other than financial, such as sales, purchasing, community relations, publicity, etc., are at this time considered for placement in these fields.

Today, graduates of the program hold responsible positions throughout the entire organization. Management positions in the accounting and financial field throughout the Company, such as Comptroller, Treasurer, finance managers, secretaries, and others, are held in large part by graduates of the course. Men who have transferred to other fields after experience in financial work include public relations executives, managers of operating divisions and departments, presidents of affiliated Companies, officials in personnel, employee relations and production divisions, and executives in many other Company activities.

This partial list of positions now filled by former business training men is indicative of the career preparation offered by the business training program, and of the opportunities that exist for qualified men interested in beginning their careers in accounting and financial work.

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